5 MW_e SNRB Demonstration Facility

Detailed Design Report 1B

SO_x-NO_x-Rox Box Flue Gas
Cleanup Demonstration Project

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DISCLAIMER

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1.0 INTRODUCTION

This document represents Public Design Report 1B for the SO_x-NO_x-Rox Box (SNRB) Flue Gas Cleanup Demonstration Project and is Deliverable D5, required for completion of Subtask 1.1.5.09 of the detailed Project Work Plan. The purpose of this report is to summarize the non-proprietary detailed engineering design of the 5 MWe SNRB field demonstration facility as of the Detailed Design Review. Process design development work is summarized in Section 2.0. This is followed by a description of the detailed engineering design in Section 3.0, including a general description of the demonstration facility. Detailed descriptions of the demonstration facility and the control system may be found under Tabs 1 and 2, respectively. Two process flow schematics and associated mass and energy balances are presented in Tab 3. Tab 4 contains site plan and general arrangement drawings for the SNRB demonstration facility. Process and instrument diagrams for selected equipment systems are presented in Tab 5.

1.1 Overview

Babcock & Wilcox's (B&W's) patented SO_x-NO_x-Rox Box process -- also known as SNRB -- has been developed to provide boiler operators with a cost-effective way to simultaneously control their emissions of the oxides of sulfur (SO_x) and nitrogen (NO_x) and particulate matter (Rox). Briefly, the process comprises the injection of both ammonia and dry sorbent upstream of a fabric filter (baghouse). A catalyst for the selective catalytic reduction (SCR) of NO_x is mounted inside the filter bags, providing for the reduction of NO_x as the flue gas/ammonia mixture passes over the catalyst. SO_x reacts with the sorbent both in the flue gas duct, and as the sorbent resides on the filter bags in the baghouse. Since the SO_x and NO_x removal processes require operation at elevated gas temperatures (550-900F), special woven, high-temperature fabric filter bags are used. Through the integration of the SO_x, NO_x, and particulate removal processes into a single unit, lower capital cost and space requirements are achieved, and operating procedures are simplified, when compared to a conventional emissions control system comprising separate wet scrubber, SCR, and particulate removal systems.

B&W is currently conducting a multi-phase project funded by the U.S. Department of Energy (DOE), the Ohio Coal Development Office/Ohio Department of Development (OCDO), and the Electric Power Research Institute (EPRI) under the DOE's Innovative Clean Coal Technology program. The objective of the B&W project is to continue the commercial development of the SNRB concept in a 5 MWe Field Demonstration Unit installed at Ohio Edison's R.E. Burger Plant located near Shadyside, Ohio. Other members of the project team include Ohio Edison (host utility), Norton Chemical Process Products Corporation (catalyst supplier), and Minnesota Mining and Manufacturing - 3M (bag supplier). The minimum emission control targets for the project include the cost-effective reduction of SO_x, NO_x, and particulate emissions to achieve:

- 70% SO_x removal
- 90% NO_x removal
- Particulate emissions in compliance with the New Source Performance Standards (NSPS) -- 0.03 lbs/million Btu.

Phase I -- Design and Permitting -- of the program involved the development of a detailed engineering design for the 5 MWe SNRB facility, and the preparation of the required environmental and permitting documents. This public design report summarizes the status of the design activity through the Detailed Design Review meeting on June 14, 1991. The design activities were supported by the operation of a 1500 ft^3/min SNRB laboratory pilot unit located at B&W's Research Center in Alliance, Ohio. Procurement of the necessary equipment, installation, and start-up has been completed under Phase II. Phase III -- Demonstration Operation and Restoration -- is underway.

1.2 SNRB Process Description

The SNRB process comprises a single process unit -- a pulse-jet fabric filter (baghouse) -- located upstream of the boiler's combustion air preheater and operating at a temperature of 550-900F. One possible arrangement of SNRB applied to a utility boiler system is illustrated in Figure 1. A special woven ceramic fabric is used for the fabrication of the filter bags to permit reliable baghouse operation at these elevated

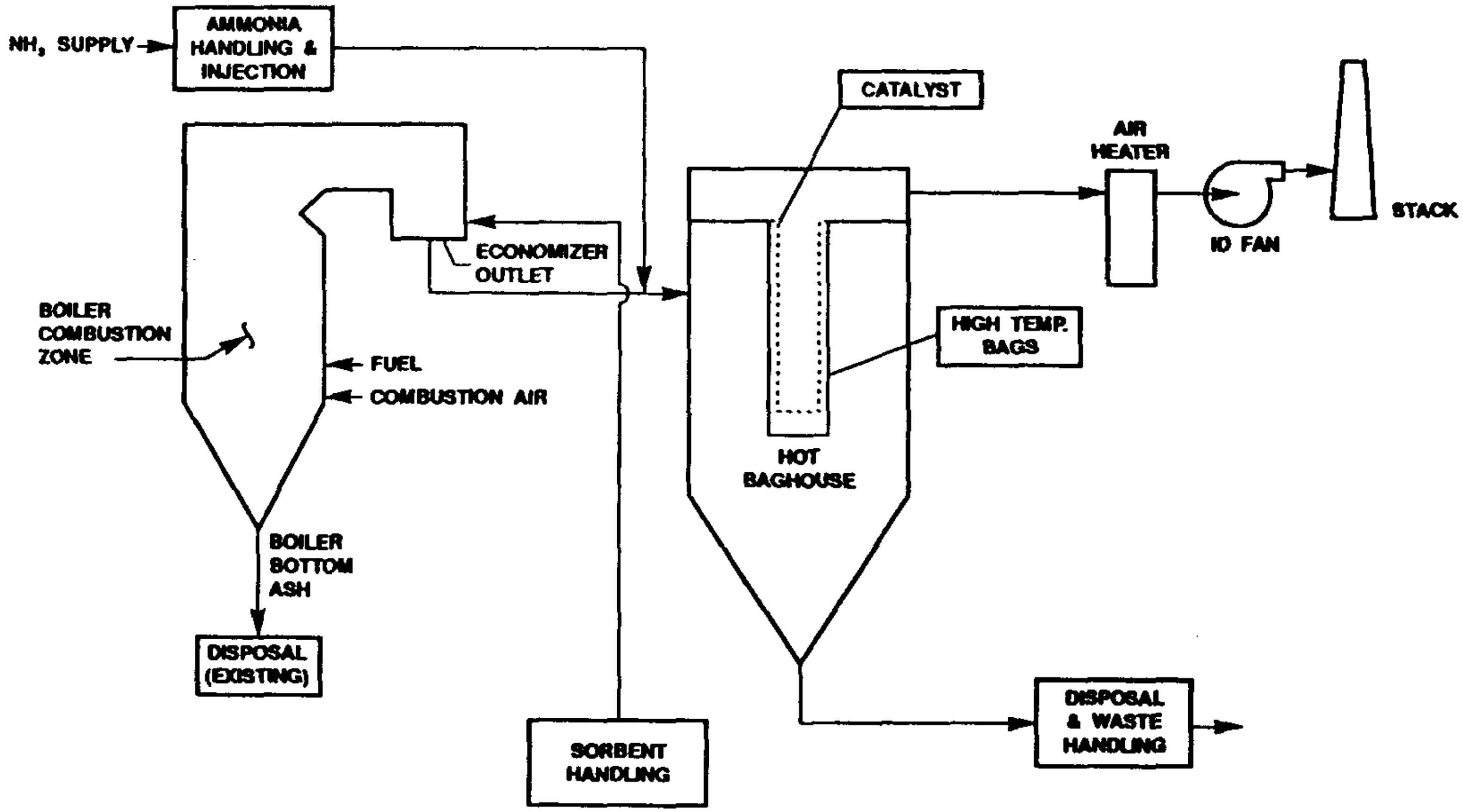

Figure 1. Possible Commercial SNRB Arrangement

temperatures. Absorption of SO_x is accomplished through the injection of a fine, dry alkali sorbent into the flue gas stream upstream of the baghouse. SO_x in the flue gas reacts with the sorbent while the latter is dispersed in the flue gas stream as it flows through the ductwork and baghouse, *and* while it resides on the filter bags in the form of filter cake. A catalyst for the selective catalytic reduction (SCR) of NO_x is installed inside the filter bags -- the clean side of the bags in a pulse-jet baghouse. By injecting ammonia into the flue gases upstream of the baghouse, NO_x is converted to harmless N_2 and H_2O as the gases pass over the catalyst. Particulate matter -- fly ash and spent sorbent -- is removed as the flue gases pass through the filter bags.

Calcium-based sorbents such as calcium hydroxide (hydrated lime) will generally provide the most cost-effective approach for SNRB applications in the eastern United States. These sorbents require baghouse operating temperatures near 850F for optimal SNRB SO_x removal performance. Sodium-based sorbents such as sodium bicarbonate ($NaHCO_3$) may be the preferred approach for the application of SNRB in the western U.S. where natural deposits of these materials occur. Baghouse operating temperatures in the range of 500-800F are anticipated with $NaHCO_3$-based systems. If maximum NO_x removal performance (90+%) is required, a promoted SCR catalyst may be needed due to the lower operating temperature of the SNRB baghouse.

The SO_x-NO_x-Rox Box process has several potential benefits:

- **One Major Component.** Capital cost and space requirements are reduced by performing the SO_x, NO_x, and particulate removal operations in a single piece of equipment.

- **Longer Catalyst Life.** SO_x and particulates are removed from the flue gas stream upstream of the SCR catalyst, minimizing catalyst poisoning, pluggage, and erosion concerns.

- **Dry Materials Handling.** Reagent preparation, handling, and disposal costs are minimized because both the fresh sorbent and waste streams are dry.

- **"Unpromoted Catalyst."** The SCR catalyst used for calcium-based SNRB systems can be an unpromoted zeolite material. This avoids the potential hazardous waste disposal concerns associated with promoted catalysts containing metals such as vanadium.

- **No Flue Gas Reheat Required.** NO_x removal upstream of the boiler air heater eliminates the need for flue gas reheat for optimal NO_x removal performance, as is required in many conventional SCR systems.

- **Increased Boiler Thermal Efficiency.** SNRB is one of the few SO_x removal processes offering the potential for a *decrease* in plant net heat rate due to the removal of SO_3 upstream of the air heater -- virtually eliminating acid dew point concerns in the combustion air preheater.

1.3 SNRB Process Development

Development of the SNRB process began at B&W in the 1970's with a series of laboratory screening tests to evaluate the applicability of a variety of materials to the catalytic reduction of NO_x. Materials such as fly ash, transition metals, and a Norton Company zeolite catalyst were evaluated. Development work then proceeded through a series of pilot-scale test programs conducted in baghouses ranging in size from 350 to 3000 ft^3/min. It was at this point that 3M's Nextel™ ceramic fiber was identified as a potential material for fabrication of the high temperature bags. Nextel™ can be used on a continuous basis at temperatures up to 1400F, with brief temperature excursions up to 2200F. These in-house development programs eventually led to two OCDO/B&W-sponsored testing programs wherein the process concept was further refined, and preliminary performance data was obtained [1]. The successful early pilot tests led to the selection of the technology for demonstration under the DOE Clean Coal Technology Demonstration Program. Laboratory pilot testing under this program has been performed in support of the design of the 5 MWe demonstration facility [2,3].

2.0 PROCESS DESIGN VERIFICATION

2.1 Laboratory Pilot Tests

Pilot-scale testing of commercial sized bag/catalyst components was completed in Phase 1 of the demonstration project. The laboratory pilot tests provided a low cost mechanism for assessing the impacts of various design and operating conditions on the overall SNRB system performance. This information and operating experience was used to finalize the design specifications for the SNRB demonstration facility.

The laboratory pilot tests confirmed that the SO_2 and NO_x emission control goals of 70% removal and 90% reduction, respectively, could be achieved simultaneously in the baghouse at 800-850F as illustrated in Figure 2. This critical observation confirmed that the operating temperature for the two control processes could be optimized without sacrificing performance of either system [3]. The pilot tests provided information on the effects of sorbent residence time in the flue work, injection temperature, and the sorbent time/temperature profile on SO_2 removal. The impact of baghouse operating temperature on SO_2 removal was also quantified in the pilot tests. NO_x emission reduction was characterized as a function of operating temperature and NH_3/NO_x ratio. Particulate and ammonia emissions downstream of the baghouse were monitored to characterize performance of the bag/catalyst assemblies in minimizing penetration and ammonia slip. The test furnace was fired with a high sulfur bituminous coal similar to that burned at the demonstration host site.

The pilot tests provided the following specific input to define the demonstration facility design and operating conditions:

- Sorbent Injection Temperature: SO_2 removal was found to be essentially independent of injection temperature over a range of 800-1100F. The demonstration facility was designed to cover this range of injection temperatures. This temperature range will be re-examined in the field demonstration test program.

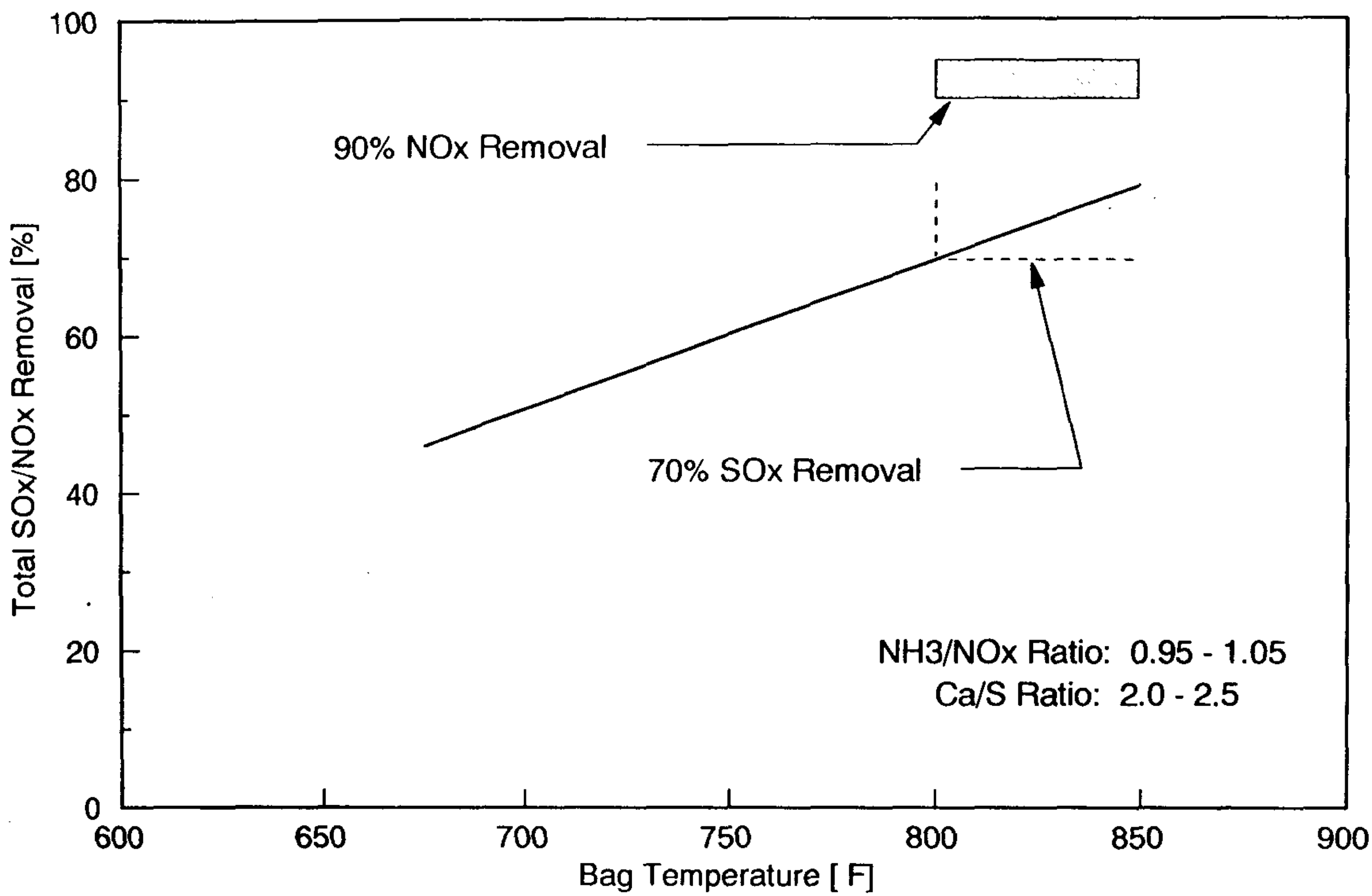

Figure 2. Effect of Baghouse Temperature on SOx and NOx Removal

- Baghouse Operating Temperature: Baghouse operation at 800-850F was required to meet the SO_2 and NO_x emission control objectives. A maximum operating temperature of 900F was specified for design of the baghouse.

- NH_3/NO_x Stoichiometry: NO_x emission reductions of 90% were achieved at NH_3/NO_x ratios of 0.9 to 1.0. This range will be used to set the maximum ammonia flow rate required based on the current NO_x emissions at the host site.

- Ca/S Stoichiometry: SO_2 removals of 70% were obtained at Ca/S ratios of 2.0 to 2.5. This range of stoichiometric ratios and the estimated current host site SO_2 emissions will be used to set the required sorbent flow rate.

- Catalyst Configuration: Evaluation of two catalyst integration arrangements resulted in selection of a monolith design for the demonstration facility. This design was selected for ease of installation, minimal particulate pluggage, flexibility, and overall economics.

- Bag/Catalyst Assembly: Experience in the pilot test program established the importance of good gasketing and sealing to minimize particulate emissions and NH_3 slip. Norton added the capability to extrude a circular monolith, and the catalyst holder was modified to minimize abrasive wear. A rope gasketing arrangement was developed to eliminate flue gas bypass of the filter bags and catalyst.

- Bag Cleaning: Reliable, consistent cleaning of the monolith catalyst/bag arrangement was demonstrated in the pilot test program. Consistent pressure drop recovery was observed with a regular, uniform cleaning cycle.

- Particulate Emissions: The pilot tests demonstrated that the Nextel™ filter bags could control emissions to less than 0.03 lb/million Btu.

- Solids Recycle: Bench-scale tests found that simple solids recycle would not improve calcium sorbent utilization under the range of injection and baghouse operating temperatures examined. Hardware provisions for incorporating solids recycle have not been included in the demonstration facility design.

2.2 Filter Fabric Development

Initial economic analysis and pilot investigations identified the critical role the filter bags will play in the technical and economic viability of the SNRB process on a commercial scale. The Filter Fabric Assessment Test program is designed to obtain extended term durability data for several alternative high-temperature bag fabrics. The test also includes an evaluation of alternative catalyst designs.

The SNRB laboratory pilot baghouse was moved from B&W's Alliance Research Center to the Martin Drake Plant located in Colorado Springs, Colorado. The pilot baghouse will draw flue gas from the economizer outlet of the 145 MWe coal-fired boiler. Inlet flue gas temperatures are expected to range from 650 to 750F. The baghouse will contain 12 full-scale bags (6 inches in diameter, 20 feet long). Three alternative bag fabrics, as well as alternative weave patterns, will be evaluated. A standard pulse-jet bag cleaning cycle based on tubesheet pressure drop will be maintained. The test will not involve full simulation of the SNRB process since SO_2 sorbent addition and ammonia injection will not be included. However significant data on bag fabric durability at elevated temperatures under normal cleaning pulse flexure conditions will be obtained.

2.3 Preliminary Economic Evaluation

A preliminary economic assessment of SNRB was conducted in conjunction with the laboratory pilot tests to provide complementary information on the cost impacts of the various potential design, performance, and operating specifications for a commercial SNRB system. The results of this study were subsequently used to prioritize the factors to be investigated in the 5 MWe facility and to determine what additional testing may be required.

Figure 3 provides a pictorial summary of the major factors contributing to the overall levelized cost (in \$/ton of SO_x+NO_x removed) of operating a 500 MWe SNRB system. The case depicted is for a calcium-based SNRB system applied to a new boiler. The various costs indicated comprise all of the incremental costs associated with the presence of the SNRB system relative to those of the "base case" boiler system without SNRB. For example, the capital cost component identified for the baghouse is actually the incremental cost of the SNRB baghouse relative to the base case particulate collector. Likewise, the cost indicated for waste disposal is the incremental cost of waste disposal for the SNRB system relative to the fly ash disposal costs of the base case. In this regard, it should be pointed out that the base case boiler system did not include SO_x or NO_x removal systems.

A detailed discussion of the economic analysis is beyond the scope of this public report. The purpose of presenting these results is to indicate the type of information used to assess the sensitivity of the overall cost of a SNRB system to the various cost factors. In particular, the figure clearly illustrates the major influence exerted by the cost of the ceramic filter bags and the SO_2 sorbent. The design of the 5 MWe facility and the associated Field Operation and Test Plan were tailored to address the sorbent cost issue; the Filter Fabric Assessment Test program was initiated to address bag cost concerns.

The final phase of the demonstration program will include a detailed engineering study for at least one typical commercial application of the technology. The results of the demonstration tests, the filter fabric tests, and the engineering study will be used to develop a detailed economic assessment of the technology.

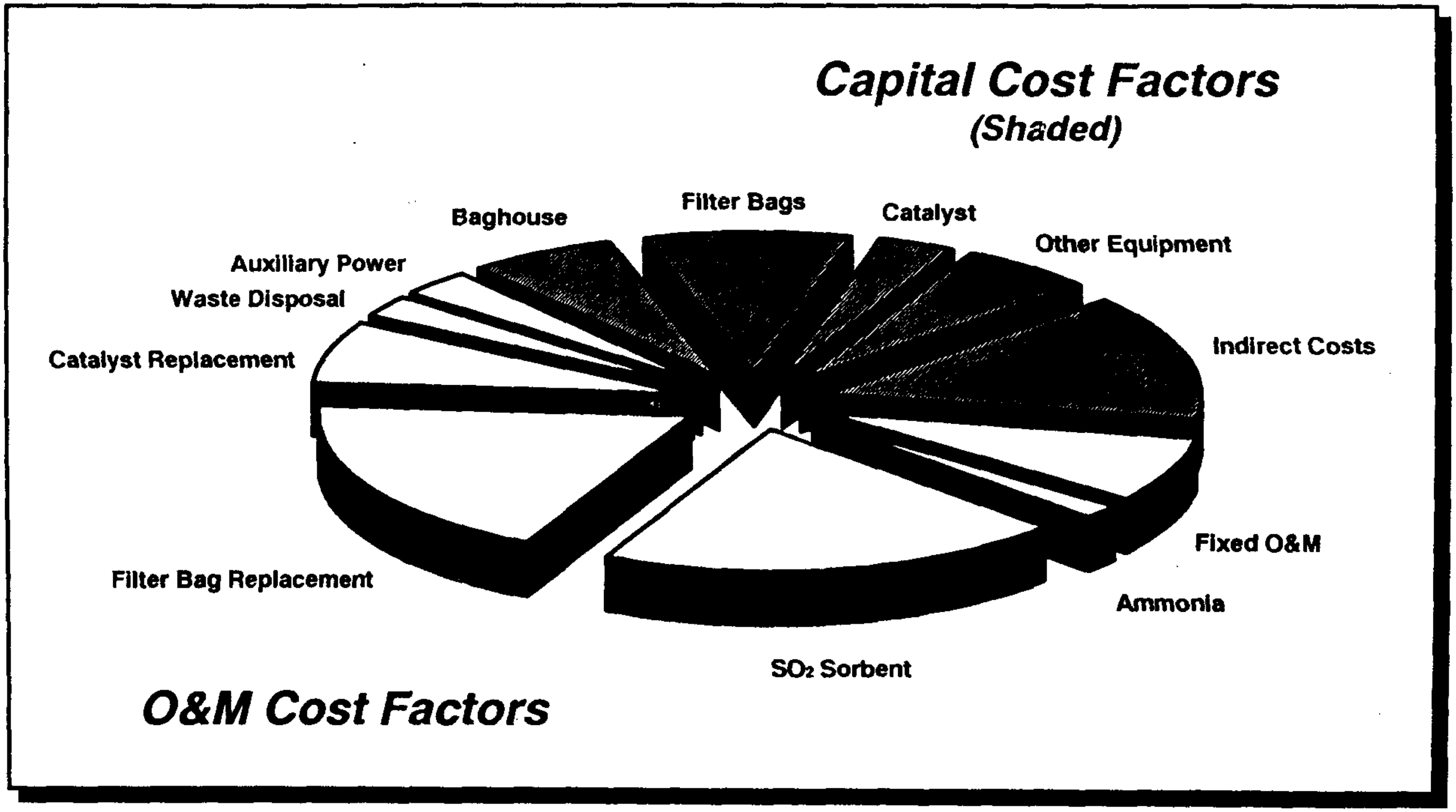

Figure 3. Breakdown of SNRB Levelized Costs

3.0 ENGINEERING DESIGN

3.1 Overview

The commercial readiness of the SNRB technology is being demonstrated at the 5 MWe Field Demonstration Facility at Ohio Edison's R. E. Burger Plant. A public dedication ceremony was held at the R. E. Burger plant on May 9, 1991, and B&W Construction Company's work on the 5 MWe facility was completed in December 1991. Testing on the unit commenced in May 1992, and will continue through the end of the year. The overall goal of the 5 MWe tests is to verify the design, operating, and performance information needed by B&W to commercialize the SNRB technology. The specific objective of the field demonstration tests is to optimize the SO_2, NO_x, and particulate removal efficiencies during operation on fully integrated, commercial-size components.

The cost effectiveness of the SNRB technology and the impacts of the process on plant equipment and operation will be evaluated. The SNRB demonstration facility will allow evaluation of issues which could not be adequately addressed at the laboratory pilot scale, including:

- Performance of the fully-integrated system on a long-term basis.
- Predictive performance curves for commercial applications.
- Control philosophy for response to boiler load changes and upsets.
- Pressure drop across the SNRB baghouse modules and bag cleaning procedures required to provide reliable long-term operation.
- Catalyst deactivation (catalyst life).
- Operating costs for the system.

Design Criteria

In order to successfully achieve the performance goals and objectives for the demonstration facility, various operational and process design criteria were established. The major design criteria are summarized in the following table:

Table 1. General Design Criteria for 5 MWe Demonstration Facility

Pilot Size:	5 MWe
Nominal Capacity:	47, 667 lb/hr (22,785 ACFM @ 650F, -8.5" H_2O)
Fuel Type:	Eastern Bituminous Source Analysis (Nominal) Ash: 10.94% S: 2.19% H: 5.09% C: 73.02% H_2O: 5.24% N_2: 1.62%
Flue Gas @ typical full load boiler operation:	Pressure at System Inlet: -8.5" H_2O Temperature at System Inlet: 650F Pressure at System Outlet: -15" H_2O
Sorbent Injection Temperature:	800 to 1100F
Ammonia Injection Temperature	500 to 900F
Baghouse Operating Temperature	500 to 900F

A complete listing of the general design criteria can be found under Tab 1 -- 5 MWe SNRB Demonstration Facility System Description. Specific process design considerations included:

- Project Performance Goals. The minimum removal efficiency goals for the project include the cost-effective reduction of SO_x, NO_x, and particulate emissions in the following manner:

- 70% SO_x removal
- 90% NO_x removal
- Particulate emissions in compliance with NSPS -- 0.03 lbs/million Btu.

- Space Limitations. A major consideration in the initial design of the demonstration facility was the site location at the power plant. In Drawing 12515J (see Tab 4), the plot plan for the demonstration facility is shown. In this drawing, the allotted site space for the demonstration facility is essentially that between the dirt road and the precipitator building, chimney, and boiler house.

- Electrical Tie-in. The 480V power supply for the SNRB demonstration facility was obtained using a spare cubicle in the existing plant switchgear. The power was obtained from the same unit which provided the flue gas take-off to eliminate the concern of cross-unit outages. An estimated power load of 770 kVA was used to size this equipment.

- Temperature Control. In the laboratory pilot tests it was found that the temperature profile of the process can have a significant effect on removal efficiency, particularly SO_2 and NO_x. Therefore, the ability both to accurately control the operating temperatures of the major sections of the facility and to vary the temperature profile to investigate a range of operating conditions was of primary concern.

- Sorbent Residence Time. While passing through the economizer the flue gases, and hence the sorbent, experience a sharp drop in temperature as heat is extracted. Testing performed during the laboratory pilot program indicated the potential importance of sorbent residence time. As a result, five different sorbent injection locations were incorporated into the design of the demonstration facility.

Features of the 5 MWe Facility

The SNRB Demonstration facility incorporates the following major features:

- A propane-fired heater for control of the sorbent injection temperature.
- Five sorbent injection locations.
- Automated ammonia injection system.
- A modular, high-temperature pulse-jet baghouse.
- Baghouse inlet and outlet flue gas heat exchangers to permit flue gas temperatures to be accurately controlled.
- Automated pneumatic sorbent feed and ash disposal systems.
- A Bailey Network 90 system for integrated process control.

A schematic of the general facility layout is presented in Figure 4. Tab 2 -- 5 MWe SNRB Demonstration Facility Control System Description -- provides a detailed discussion of the control philosophy for each major equipment system. Assorted detailed process schematics can be found under the following tab numbers:

- Tab 3: Process Flow Schematics/Mass and Energy Balances
- Tab 4: Site Plan and General Arrangement Drawings
- Tab 5: Process and Instrument Diagrams

3.2 5 MWe Demonstration Facility Description

A 23,000 acfm flue gas slipstream from Ohio Edison's R. E. Burger Plant Boiler No. 8 air heater ash collection hopper provides the flue gas source for the demonstration facility (see Figure 5). To elevate the gas temperature from approximately 650F to the desired temperature window for sorbent injection, the fluework system is equipped with a propane-fired burner. This burner will permit evaluation of sorbent injection temperatures up to 1100F. The flue gas is then cooled to the desired baghouse operating temperature as it passes through an air-air, plate-type heat exchanger. The metal surface

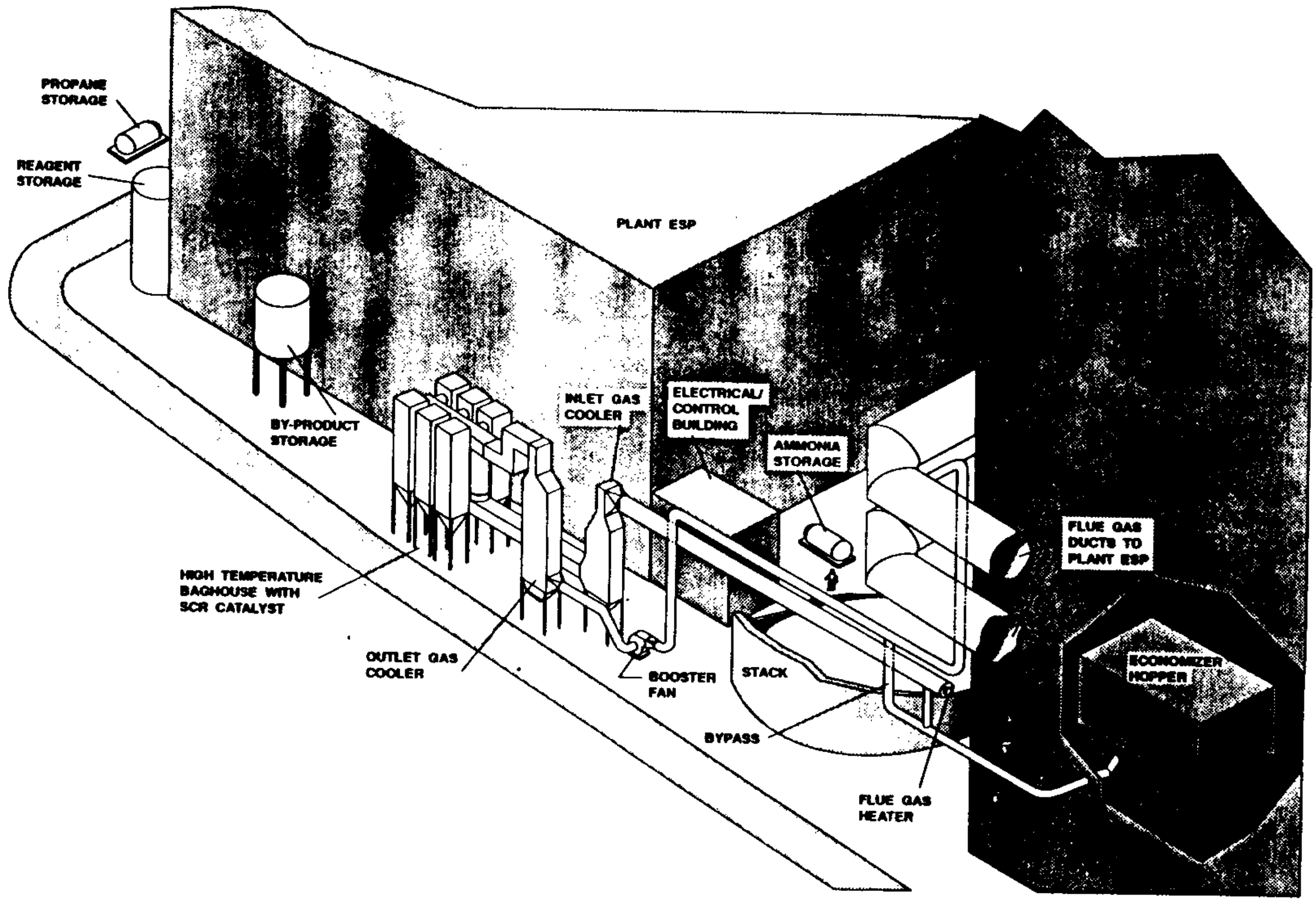

Figure 4. Layout Schematic for 5 MW Demonstration Facility

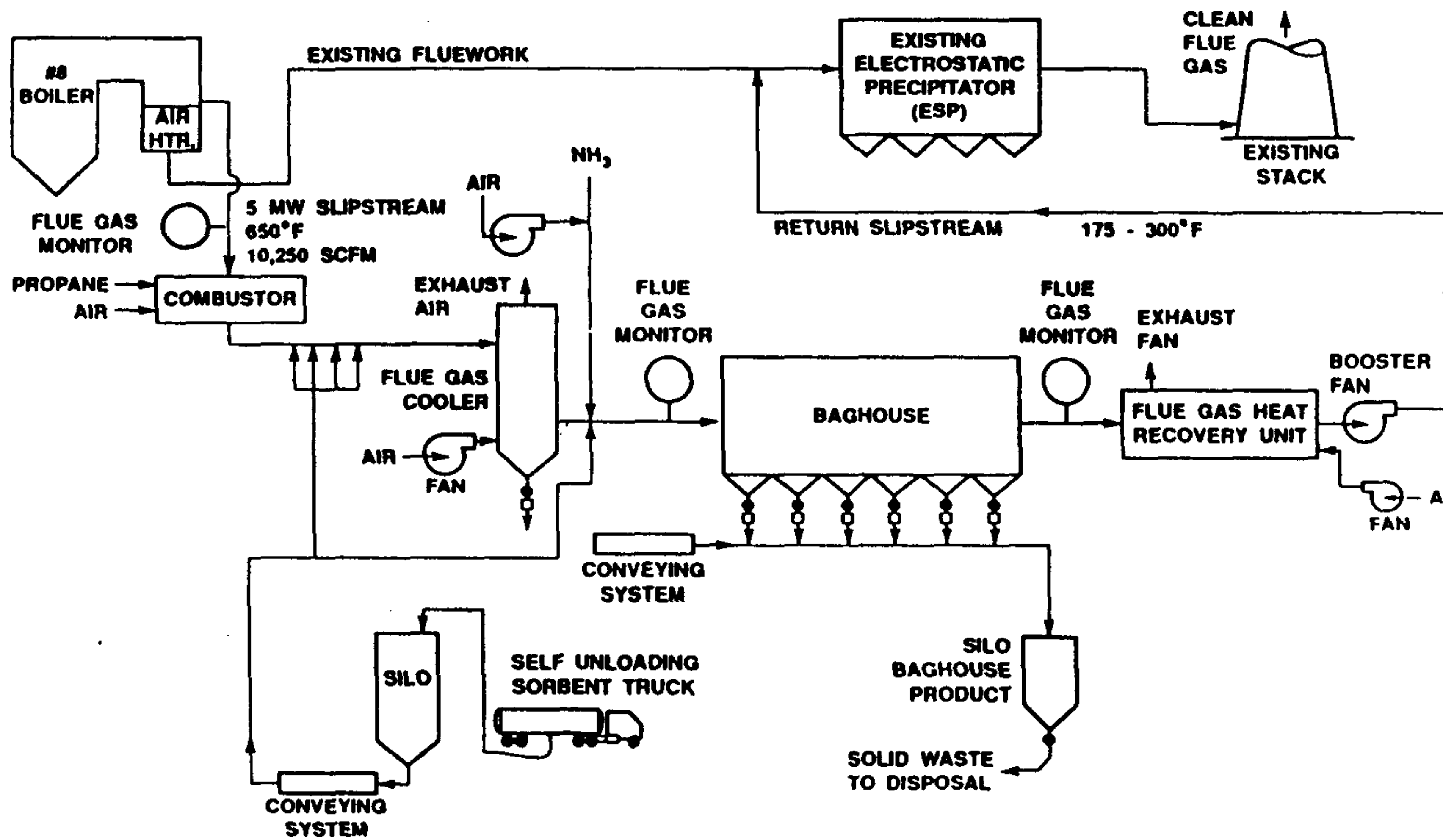

Figure 5. Process Flow Schematic for 5 MW Demonstration Facility

temperatures, gas residence time, and flue gas quench rate of this heat exchanger were designed to simulate those encountered in utility boiler economizer sections.

An ammonia/air mixture supplied by a packaged ammonia injection system is injected upstream of the baghouse. The sorbent feed system consists of a fresh sorbent storage silo, a loss-in-weight type feeder to accurately meter the sorbent feed rate, and a pneumatic transport system to convey the sorbent to one of five injection locations in the fluework. Four of the injection ports are located in the high-temperature, refractory-lined fluework between the propane-fired burner and the inlet gas cooler, while the fifth is located between the inlet gas cooler and the baghouse. These multiple injection locations will provide the necessary flexibility to evaluate a wide range of residence time/temperature profiles during the testing program.

The baghouse is equipped with a pneumatic ash removal system that transports the fly ash and SNRB process by-products to a storage silo. The ash storage silo is equipped for truck loading operation. The fly ash will be disposed of off-site at an approved solid waste landfill.

After exiting the baghouse, the flue gas is cooled further as it passes through a second air-air, plate-type heat exchanger. This outlet gas cooler has been designed to permit evaluation of the corrosive effects of SO_3 concentrations in the exit flue gas stream at temperatures as low as 170F. This feature will permit evaluation of the potential for improved boiler efficiency through additional heat recovery at the combustion air preheater. Finally, the flue gas passes through the system booster fan before it is introduced into the existing Boiler No. 8 electrostatic precipitator inlet flue.

3.3 High-Temperature Baghouse Description

The baghouse has been designed for operation at gas temperatures up to 900F. The baghouse consists of six modules arranged in a three-by-two array. Each of the six modules contains 42 full-size, integrated bag/catalyst assemblies. The baghouse was sized for a nominal air-to-cloth ratio of 4:1 at a gas flow of 30,000 acfm at a gas temperature of 800F. The hot flue gas entering the baghouse is distributed to the bottom of each of the six modules through a tapered inlet manifold. Manually operated butterfly dampers are used for module inlet isolation. The clean gas exits each module at the top and is collected in a tapered clean gas manifold. Pneumatically operated poppet valves are utilized for module outlet isolation. A bypass manifold, containing a pneumatically operated poppet valve, connects the inlet and outlet gas manifolds to automatically protect the baghouse in the event of a system upset.

The pulse-jet cleaning system is designed to permit either on-line or off-line cleaning in either manual or automatic operating modes. For additional flexibility during testing, in the automatic mode the fully adjustable cleaning cycle may be initiated on either baghouse pressure differential, timed, or combined pressure differential/timed basis.

The baghouse modules are fitted with removable clean gas plenums to facilitate installation, inspection, and replacement of the bag/catalyst assemblies. A weather-proof enclosure covers the entire roof area of the baghouse system, and is equipped with a hoist/monorail system to assist in handling of the module clean gas plenums and bag/catalyst assemblies.

3.4 Description of System Packages

The demonstration facility has been broken down into several major and auxiliary system packages. A listing of these packages is presented in Table 2. A detailed summary of the major components and primary design criteria for each major system is included in the following Tables 3 through 14. Figures 6 through 17 present sections of the detailed arrangement drawings (B&W drawings numbered 12584J, 12585J, and 12587J) which include the components of each package as appropriate. These drawings are included in Tab 4.

Table 2. 5 MWe SNRB Demonstration Facility System Packages

Major System Packages	Auxiliary System Packages
Compressed Air	Flue Gas Analyzers
Process Control	Data Acquisition
Induced Draft Fan	Heat Tracing
Propane Storage/Heater	Service and Potable Water
Reagent Storage/Injection	
Inlet Flue Gas Cooler	
Ammonia Storage/Injection	
Baghouse	
Ash Removal/Storage	
Outlet Flue Gas Cooler	

Compressed Air System

The compressed air system is designed to provide pressurized air for operation of the pneumatically driven equipment, the baghouse cleaning cycle, instrument air, and general service air. The components of the compressed air supply system are summarized in Table 3. Figure 6 illustrates the location of the compressed air supply system at the demonstration facility.

Process Control System

A detailed discussion of the process control system is presented in Tab 2. Table 4 summarizes the design criteria for the process control system.

TABLE 3

COMPRESSED AIR SYSTEM

SYSTEM SUPPLIER	INGERSOLL-RAND
MAJOR COMPONENTS	PACKAGED AIR COMPRESSOR INSTRUMENT AIR RECEIVER SERVICE AIR RECEIVER INSTRUMENT AIR DRYER INSTRUMENT AIR FILTERS AIR PIPING SYSTEMS
DESIGN CRITERIA	
COOLING MEDIA	AMBIENT AIR
HORSEPOWER	100
INSTRUMENT AIR RECEIVER CAPACITY	400 gallons
SERVICE AIR RECEIVER CAPACITY	80 galllons
COMPRESSOR INLET CONDITIONS	
FLOW RATE	431 SCFM
TEMPERATURE	60 F
PRESSURE	29.18 in Hg
COMPRESSOR DISCHARGE CONDITIONS	
FLOW RATE	442 ACFM
TEMPERATURE	75 F
PRESSURE	125 psig

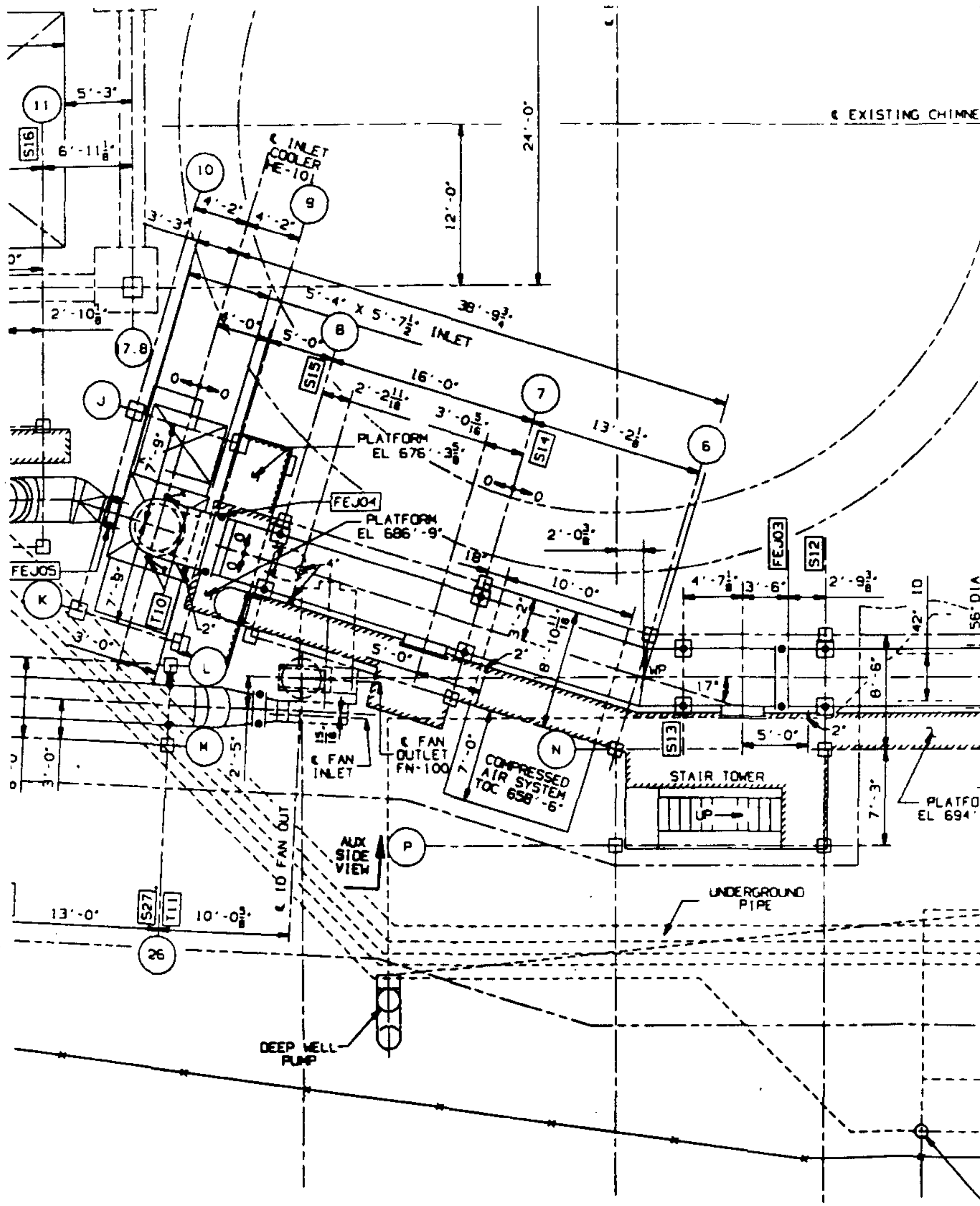

Figure 6. Air Compressor Location

TABLE 4

PROCESS CONTROL SYSTEM

SYSTEM SUPPLIER	BAILEY CONTROLS COMPANY
MAJOR COMPONENTS	NETWORK 90 MICROPROCESSOR CONFIGURATION MODULE VISUAL ALARM PANEL CHART RECORDERS DIGITAL INDICATING STATIONS DIGITAL CONTROL STATIONS POWER SUPPLY
FEATURES	
MANUAL/AUTOMATIC CONTROL	
DATA ACQUISITION INTERFACE	
LOCAL CONTROL PANEL INTERFACES	
EQUIPMENT START PERMISSIVES	
OPERATING INTERLOCKS	
PROCESS STATUS ALARMS	
DIGITAL INPUTS, 120 VAC	30
ANALOG INPUTS, 4-20 mA DC	29
THERMOCOUPLE INPUTS	31
DIGITAL OUTPUTS, 24 VDC	54
RELAY OUTPUTS	8
CONTROL OUTPUTS, 4-20 mA DC	7

Induced Draft Fan

The induced draft (ID) fan is used to pull flue gas into the demonstration facility fluework from the boiler #8 air preheater ash collection hopper and return flue gas to the ESP inlet fluework. Design information for the fan is summarized in Table 5. Figure 7 indicates the location of the fan at the demonstration facility.

Propane Storage/Heater System

The propane heater is designed to raise the flue gas temperature from that available at the boiler #8 take-off to approximately 1100F to simulate the temperature range for sorbent injection in the economizer section of a boiler. Propane is supplied to the heater through the propane storage and supply system. The components of the propane supply and heater system are summarized in Table 6. The propane storage tank and the propane-fired heater are illustrated in Figures 8 and 9.

Reagent Storage/Injection System

The reagent storage and injection system includes all of the equipment required for storage and supply of dry sorbents for reaction with SO_2 in the flue gas. The required equipment and design criteria are presented in Table 7. The location of the reagent storage silo is depicted in Figure 10. The reagent injector port locations are illustrated in Figure 11.

Inlet Flue Gas Cooler System

The purpose of the inlet flue gas cooler system is to simulate the cooling of the flue gas which would occur as the flue gas passes through the economizer section of a utility boiler. The flue gas cooler provides operating flexibility by permitting control of the baghouse operating temperature independent of the sorbent injection temperature. The design criteria for the inlet flue gas cooler system is summarized in Table 8. Figure 12 illustrates how the inlet flue gas cooler is integrated into the facility.

TABLE 5

INDUCED DRAFT FAN

SYSTEM SUPPLIER	ZURN INDUSTRIES
MAJOR COMPONENTS	FAN INLET BOX EVASE MOTOR / COUPLING COMMON BASE CONTROLS
DESIGN CRITERIA	
MOTOR HORSEPOWER	100
SPEED	1775 RPM
MAXIMUM GAS TEMPERATURE	600 F
TEST BLOCK PERFORMANCE	
GAS FLOW	61,600 lb/hr
GAS FLOW	17,800 ACFM
GAS TEMPERATURE	170 F
STATIC PRESSURE	21.2 inches water
EFFICIENCY	86%
HORSEPOWER	69
NET FLOW PERFORMANCE	
GAS FLOW	56,000 lb/hr
GAS FLOW	16,200 ACFM
GAS TEMPERATURE	170 F
STATIC PRESSURE	21.9 inches water
EFFICIENCY	84%
HORSEPOWER	67

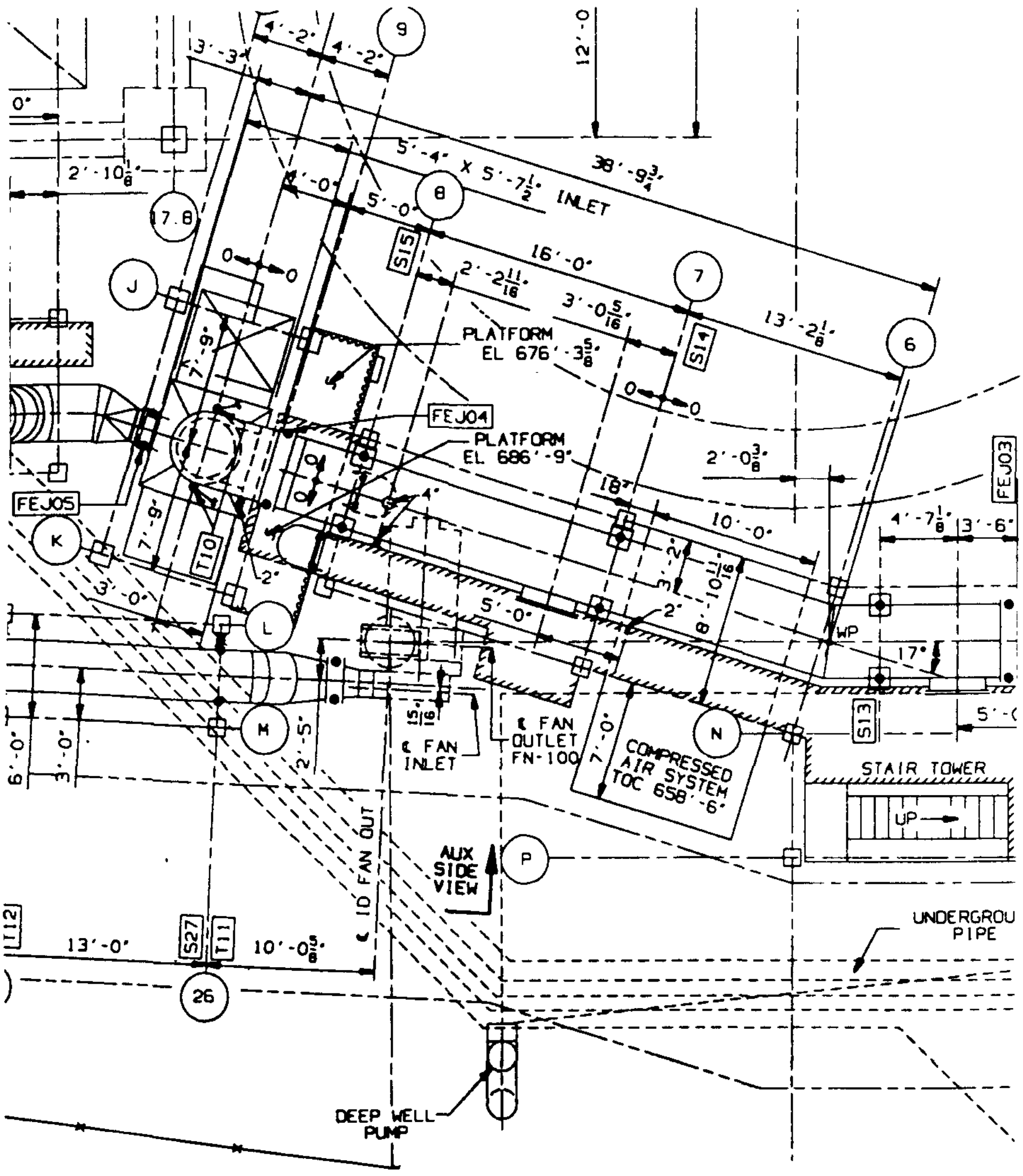

Figure 7. ID Fan Location

TABLE 6

PROPANE STORAGE/HEATER SYSTEM

SYSTEM SUPPLIERS	STORAGE - PLANT SYSTEMS INC. HEATER - ECLIPSE COMBUSTION
MAJOR COMPONENTS	LP STORAGE TANK LP PUMP AND VAPORIZER BURNER SUPPLY PIPING BURNER COMBUSTION AIR FAN COMBUSTION CONTROLS FLAME SAFETY SYSTEM
DESIGN SPECIFICATIONS	MEETS NFPA, FM AND IRI REQUIREMENTS
DESIGN CRITERIA - STORAGE/SUPPLY	
TANK SIZE/WORKING CAPACITY	18,000/15,300 GALLONS
DAYS STORAGE	19 DAYS @ 10 hrs/day and 7.15 MMBtu/hr 8 DAYS @ 24 hrs/day and 7.15 MMBtu/hr
VAPORIZER CAPACITY	79 gph @ 7.15 MMBtu/hr DEMAND 169 gph @ -20 F (MAXIMUM)
SUPPLY LINE PRESSURE	5 psi @ TANK AND 1 psi @ BURNER
DESIGN CRITERIA - BURNER	
HEAT INPUT	7.15 MMBtu/hr @ FULL GAS FLOW AND 1000 F OUTLET TEMPERATURE 14.0 MMBtu/hr (MAXIMUM)
TURNDOWN	70 : 1
EFFICIENCY	61%
COMBUSTION AIR FLOW	4462 lb/hr @ FULL GAS FLOW AND 1000 F OUTLET TEMPERATURE 8625 lb/hr (MAXIMUM)

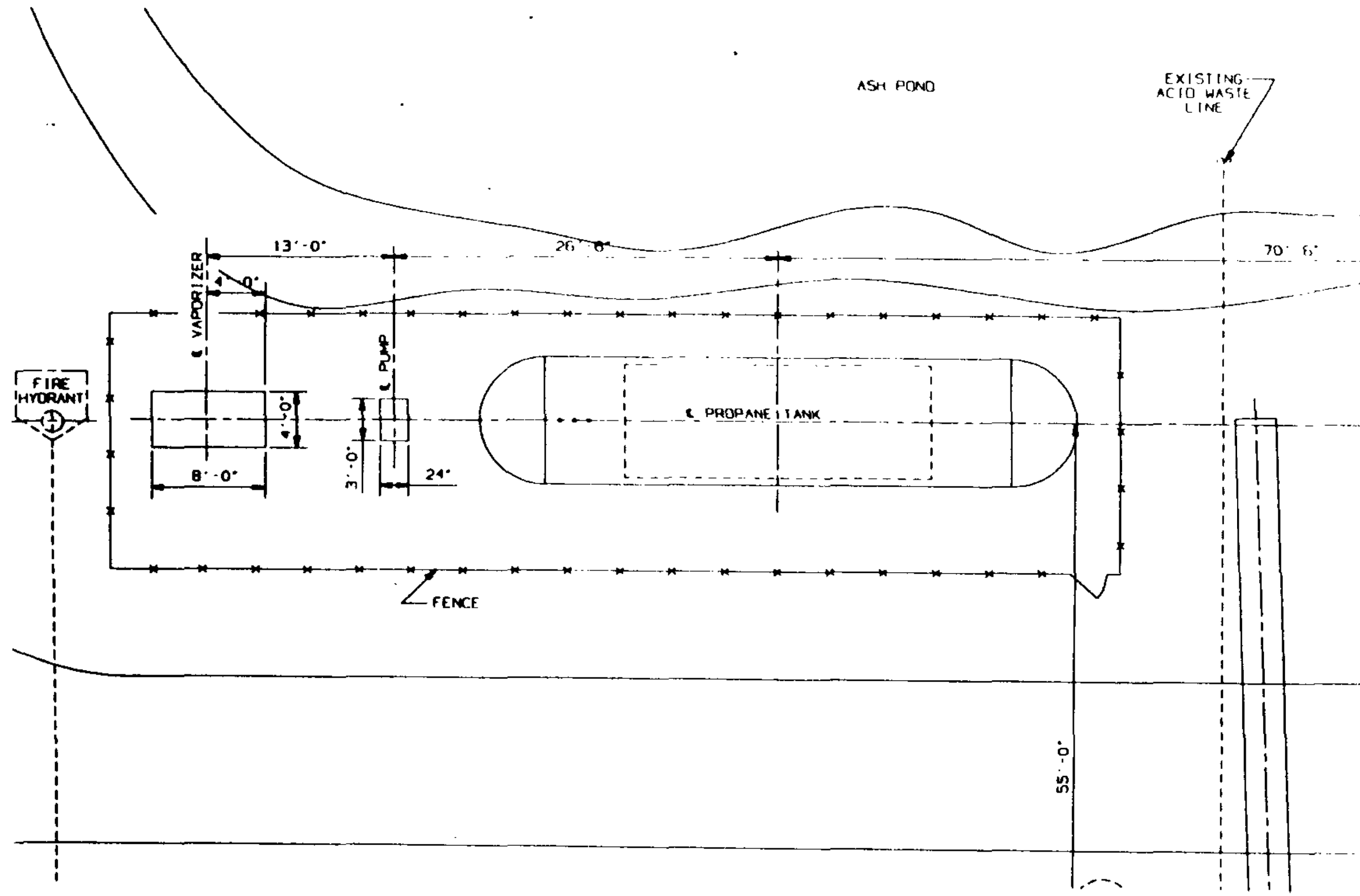

Figure 8. Propane Storage Tank Location

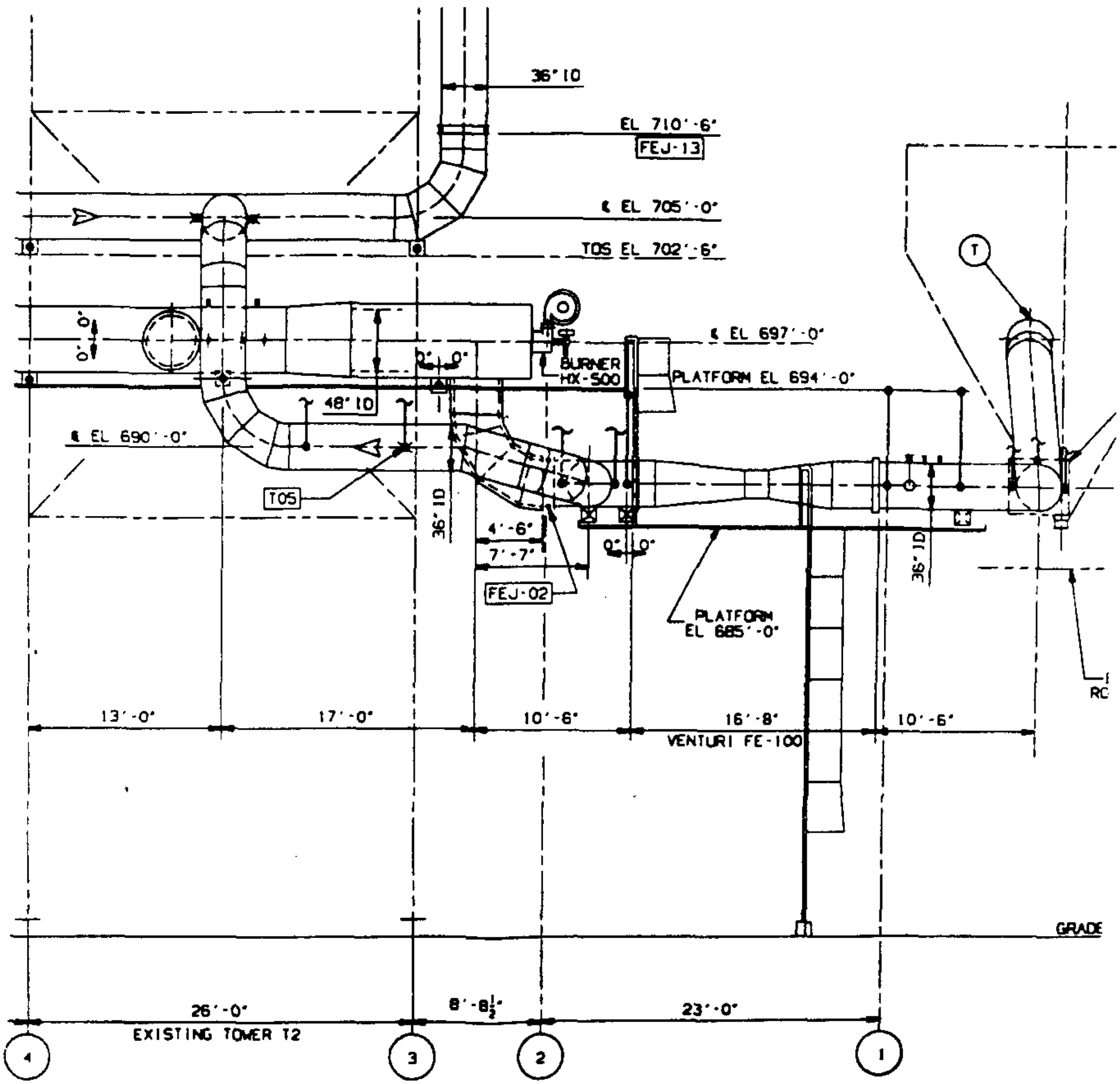

Figure 9. Propane Fired Flue Gas Heater

TABLE 7

REAGENT STORAGE/INJECTION SYSTEM

SYSTEM SUPPLIER	SMOOT COMPANY
MAJOR COMPONENTS	REAGENT STORAGE SILO LOSS-OF-WEIGHT FEEDER ROTARY AIRLOCK FEEDERS (2) AIRLOCK FEEDER HOPPER/FILTER VARIABLE SPEED BLOWER TRANSPORT PIPING SYSTEM INJECTOR PIPING
DESIGN CRITERIA	
STORAGE SILO	
SIZE	12' DIAMETER X 42' HIGH
CAPACITY	2,350 ft3 (35 tons @ 30 lb/ft3)
DAYS STORAGE	
HYDRATED LIME	10 days @ 10 hrs/day and 704 lb/hr 4 days @ 24 hrs/day and 704 lb/hr
SODIUM BICARBONATE	8 days @ 10 hrs/day and 897 lb/hr 3 days @ 24 hrs/day and 897 lb/hr
LOSS-IN-WEIGHT FEEDER RANGE	100 - 1,200 lb/hr
TRANSPORT	
FULL GAS LOAD FLOW RATE	
HYDRATED LIME	704 lb/hr
SODIUM BICARBONATE	897 lb/hr
INJECTION LOCATIONS	
HYDRATED LIME	(4) - 0.2, 0.5, 1.0, & 2.0 sec FROM INLET GAS COOLER
SODIUM BICARBONATE	(1) - 0.5 sec FROM BAGHOUSE

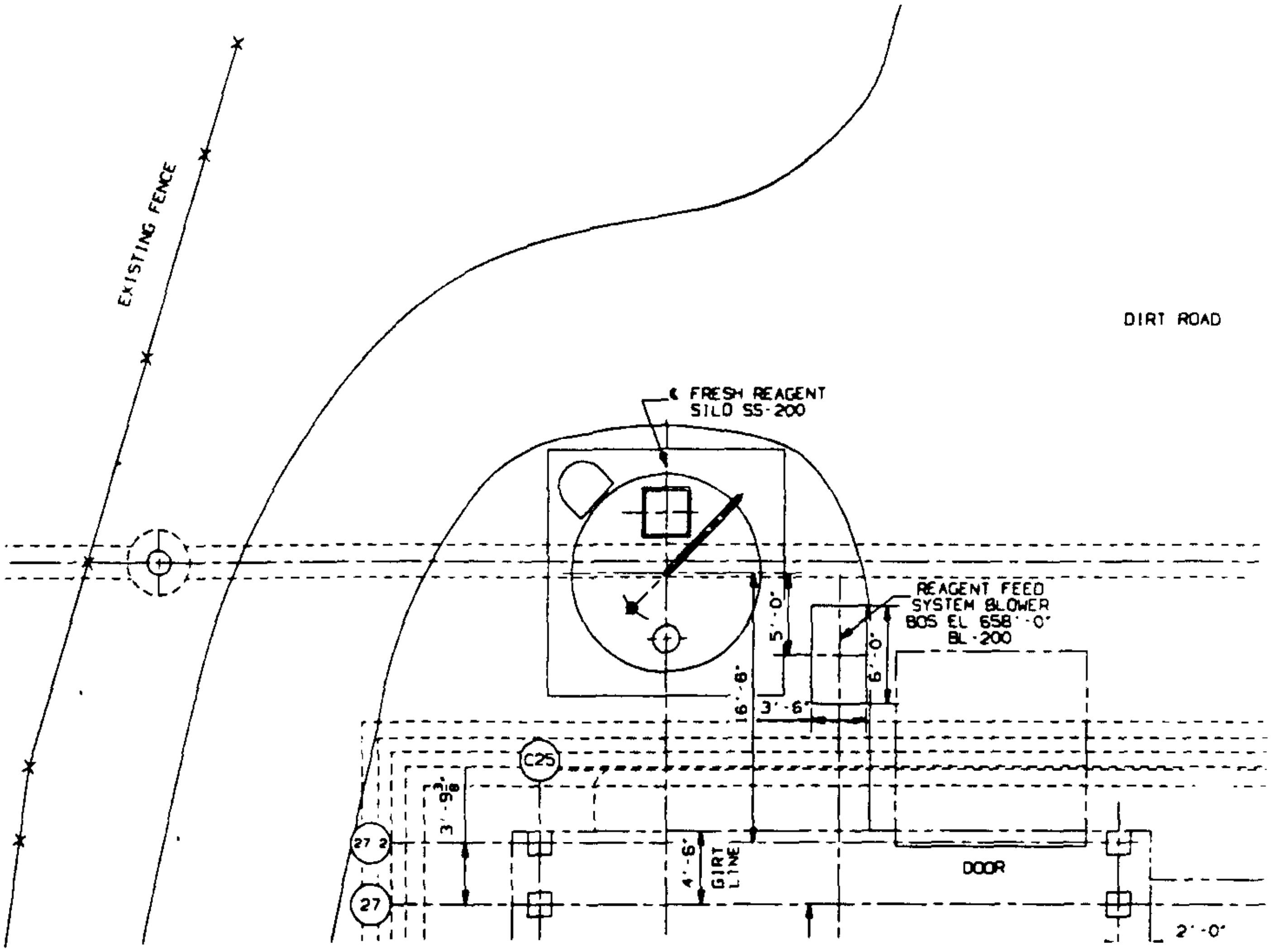

Figure 10. Reagent Storage Silo Location

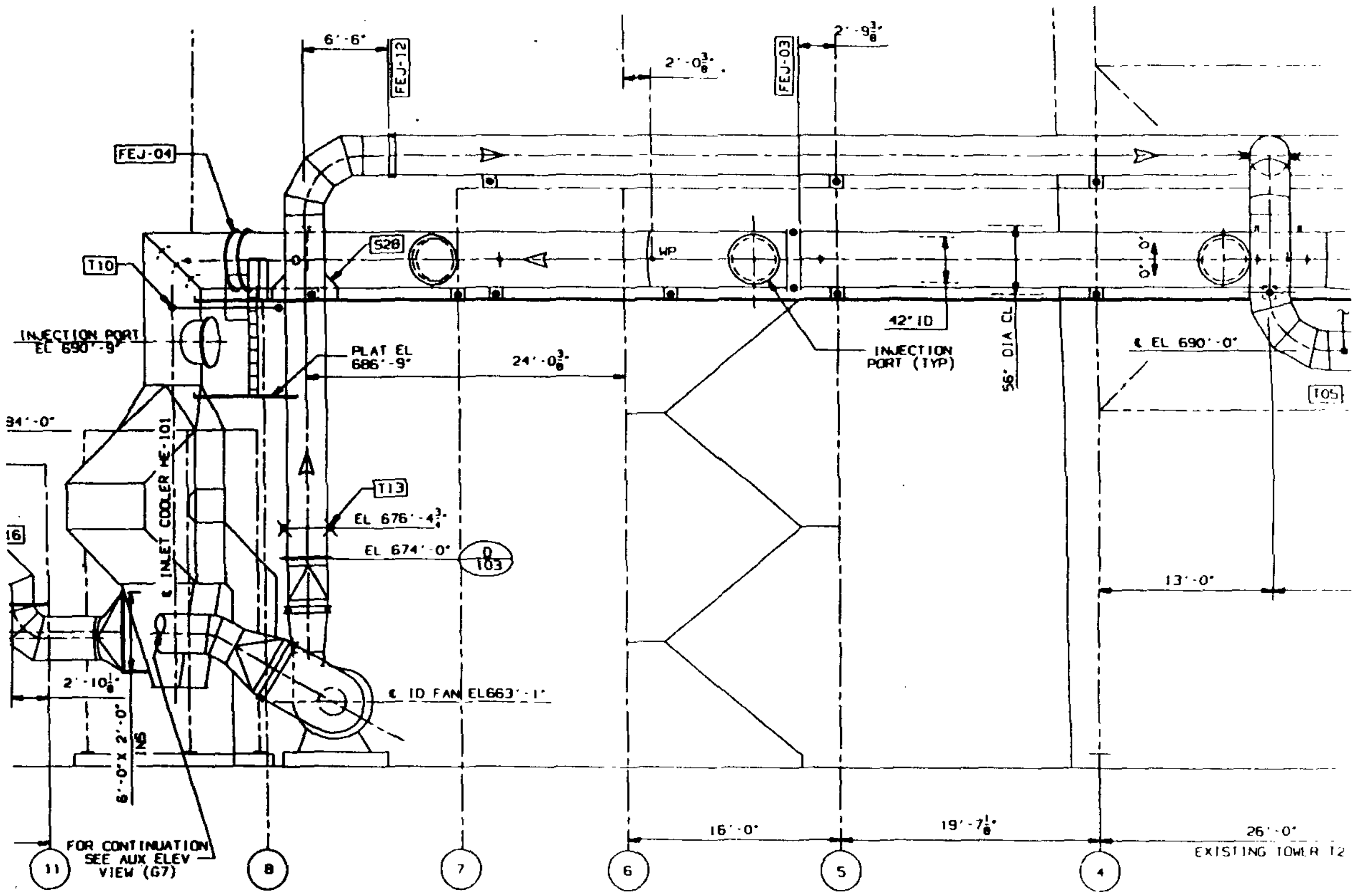

Figure 11. Reagent Injector Port Locations

TABLE 8

INLET GAS COOLER SYSTEM

SYSTEM SUPPLIER	NORTH ATLANTIC TECHNOLOGIES
MAJOR COMPONENTS	INLET BLOCK - 304 SS OUTLET BLOCK - ALUMINIZED COOLING AIR FAN COOLING AIR DUCTS COOLING AIR CONTROL DAMPER SUPPORTS/PLATFORMS
DESIGN CRITERIA	
GAS FLOW	54,023 lb/hr @ FULL LOAD
INLET GAS TEMPERATURE	1200 F
OUTLET GAS TEMPERATURE	700 F
COOLING AIR FLOW	49,000 lb/hr
INLET AIR TEMPERATURE	95 F
OUTLET AIR TEMPERATURE	720 F
PRESSURE DROP	1.25 inches water
HEAT EXCHANGED	7.59 MMBtu/hr
HEAT TRANSFER SURFACE	4,019 ft2
GAS VELOCITY	45 ft/sec
GAS RESIDENCE TIME	0.26 seconds
HEAT TRANSFER CHARACTERISTICS	
OVERALL TRANSFER COEFFICIENT	4.0 Btu/hr-ft2-F
MAXIMUM GAS OUTLET TEMPERATURE	900 F
MINIMUM METAL TEMPERATURE	320 F
HEAT TRANSFER RANGE	8.35 - 1.91 MMBtu/hr

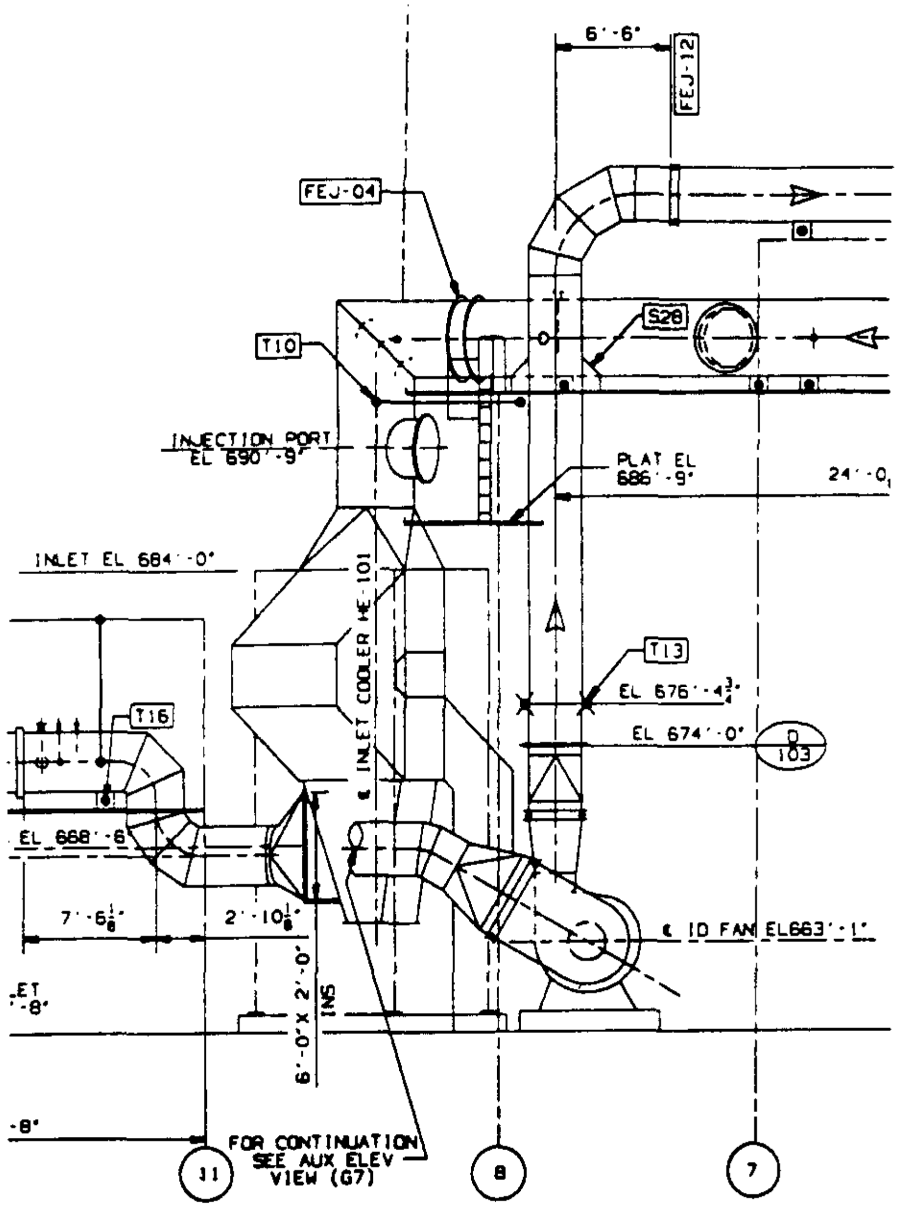

Figure 12. Inlet Flue Gas Cooler

Ammonia Storage/Injection System

The ammonia injection system is designed for ammonia storage and supply of ammonia vapor to the inlet of the baghouse. In the baghouse, the ammonia reacts with NO_x in the flue gas on the catalyst surface to reduce the NO_x to nitrogen and water vapor. The components of the ammonia injection system are detailed in Table 9. The location of the skid-mounted ammonia storage and injection system is illustrated in Figure 13.

Baghouse System

The high temperature, pulse-jet baghouse is the center of the SNRB demonstration facility. The baghouse is designed for collection of the fly ash and the SO_2/sorbent reaction products while operating at a high temperature for optimal NO_x removal performance. The baghouse system design criteria is summarized in Table 10. Figure 14 illustrates how the baghouse is connected with the inlet and outlet fluework.

Ash Removal/Storage System

The ash removal system is designed to transport solid waste from the baghouse collection hoppers to an intermediate storage silo prior to off-site disposal in a solid waste landfill. A totally enclosed, pneumatic system has been designed to minimize the potential for particulate emissions. The components of the ash removal and storage system are detailed in Table 11. The major components of the ash transport system are shown in Figure 15 and the ash storage silo is shown in Figure 16.

Outlet Flue Gas Cooler System

The outlet flue gas cooler system has been designed to simulate the change in flue gas temperature as it passes through an air heater in a utility boiler cycle. The flue gas cooler will be used to reduce the flue gas temperature to permit evaluation of the potential for acid deposition using an air-cooled deposition probe in the outlet fluework. The outlet flue gas will not be reduced below the acid dew point to prevent condensation and

TABLE 9

AMMONIA STORAGE/INJECTION SYSTEM

SYSTEM SUPPLIER	FERGUSON INDUSTRIES
MAJOR COMPONENTS	NH3 UNLOADING TERMINAL NH3 STORAGE TANK ELECTRIC VAPORIZER DILUTION AIR BLOWER NH3 / AIR MIX STATION CONTROLS/INSTRUMENTATION PIPING SYSTEM NH3 INJECTOR NOZZLES
DESIGN CRITERIA	
STORAGE	
TANK SIZE	1000 gallons
TANK WORKING CAPACITY	850 gallons
DAYS STORAGE	24 days @ 10 hrs/day and 18 lb/hr 10 days @ 24 hrs/day and 18 lb/hr
VAPORIZER CAPACITY	27 lb/hr MAXIMUM
TRANSPORT	
AIR TO NH3 RATIO	19 : 1 ON MOLAR BASIS
NH3 FLOW @ FULL LOAD	18 lb/hr
AIR FLOW @ FULL LOAD	591 lb/hr
DILUTION AIR FAN CAPACITY	1,125 lb/hr
SYSTEM NH3 FLOW RANGE	2 - 35 lb/hr

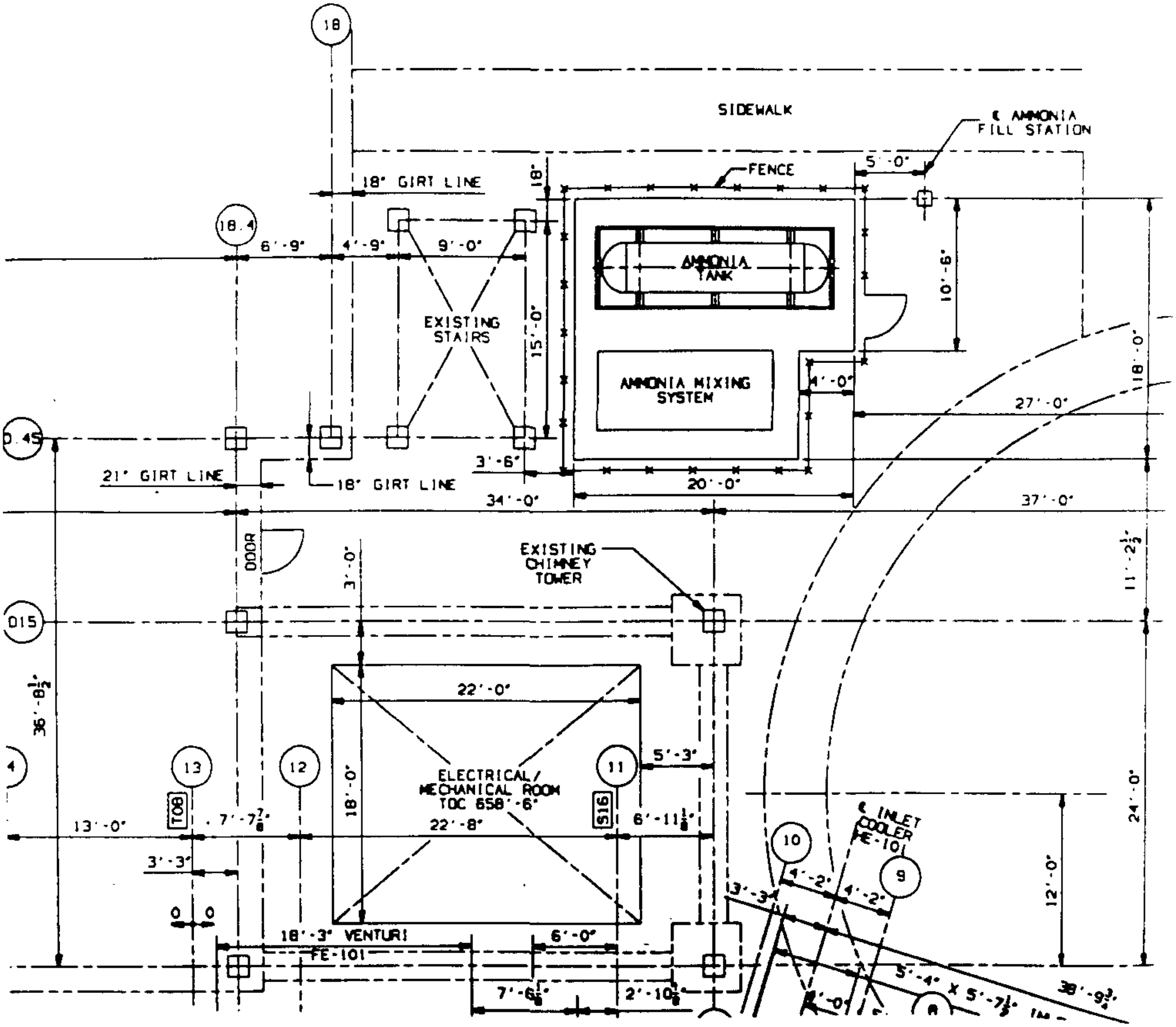

Figure 13. Package Ammonia Injection System Location

TABLE 10

BAGHOUSE SYSTEM

SYSTEM SUPPLIER	AMEREX
MAJOR COMPONENTS	MODULES (6) INLET GAS MANIFOLD OUTLET GAS MANIFOLD BYPASS SYSTEM PENTHOUSE ENCLOSURE SUPPORT STEEL/ACCESS PLATFORMS PULSE JET CLEANING SYSTEM CONTROLS & INSTRUMENTATION
DESIGN CRITERIA	
GAS VOLUME	29,934 ACFM @ 800 F
NUMBER OF MODULES	6
COMPARTMENT ARRANGEMENT	3 X 2 WITH CENTER GAS MANIFOLDS
NUMBER OF BAGS/MODULE	42
TOTAL NUMBER OF BAGS	252
BAG SIZE	6" DIAMETER X 20' LONG
BAG SPACING	3" CLEAR SPACE BETWEEN BAGS
EFFECTIVE CLOTH AREA/BAG	30.63 ft2
TOTAL CLOTH AREA	7,719 ft2
AIR-TO-CLOTH RATIO	3.88 : 1 - ALL MODULES ON-LINE 4.65 : 1 - ONE MODULE OFF-LINE
CLEANING	
TYPE	ON-LINE OR OFF-LINE CLEANING
CYCLE CONTROL	TIME, DIFF. PRESSURE OR MANUAL
PULSE AIR PRESSURE	80-100 psi ON-LINE 60 psi OFF-LINE

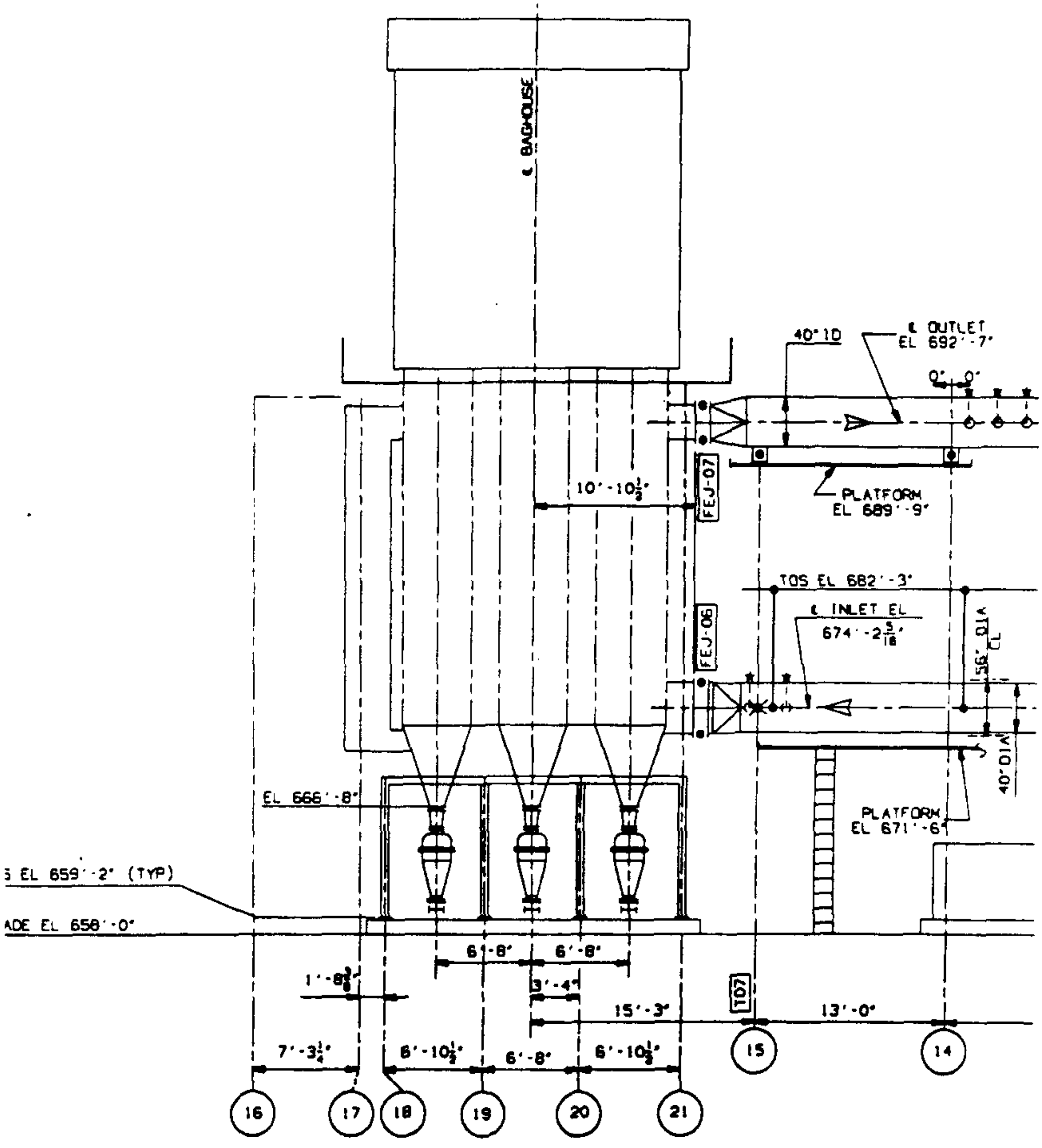

Figure 14. Baghouse and Fluework

TABLE 11

ASH REMOVAL/STORAGE SYSTEM

SYSTEM SUPPLIER	UNITED CONVEYOR CORPORATION
MAJOR COMPONENTS	NUVA FEEDER ASSEMBLIES (6) TRANSPORT BLOWER TRANSPORT PIPING TRANSPORT SYSTEM CONTROLS ASH STORAGE SILO BIN VENT FILTER SILO FLUIDIZING SYSTEM UNLOADING AIRLOCK FEEDER UNLOADING AIR SLIDE UNLOADING SYSTEM CONTROLS
DESIGN CRITERIA	
STORAGE SILO	
SIZE	10' DIAMETER X 15' HIGH
CAPACITY	1,021 ft3 (15 tons @ 30 lb/ft3) 1,021 ft3 (31 tons @ 60 lb/ft3)
DAYS STORAGE	
HYDRATED LIME @ SR=2	6 days @ 10 hrs/day and 1,032 lb/hr
BYPRODUCT @ 60 lb/ft3	2.5 days @ 24 hrs/day and 1,032 lb/hr
FLUIDIZING BLOWER	80 ACFM @ 4.5 PSIG
UNLOADING RATE	4,550 lb/hr
UNLOADING TIME	7 hrs @ 30 lb/ft3 13 hrs @ 60 lb/ft3
ASH COLLECTION	
BAGHOUSE HOPPER VOLUME	31.5 ft3
BAGHOUSE HOPPER ASH WEIGHT	1,890 lb @ 60 lb/ft3
HOPPER FLUIDIZING BLOWER	54 ACFM @ 4.5 PSIG
TIME TO EMPTY FULL HOPPERS	4.8 hrs @ 60 lb/ft3
NUVA FEEDER SIZE	4 ft3 EACH
NUVA FEEDER CAPACITY	2,340 lb/hr TOTAL
TRANSPORT	
CONVEYING BLOWER	403 ACFM @ 6.7 psig

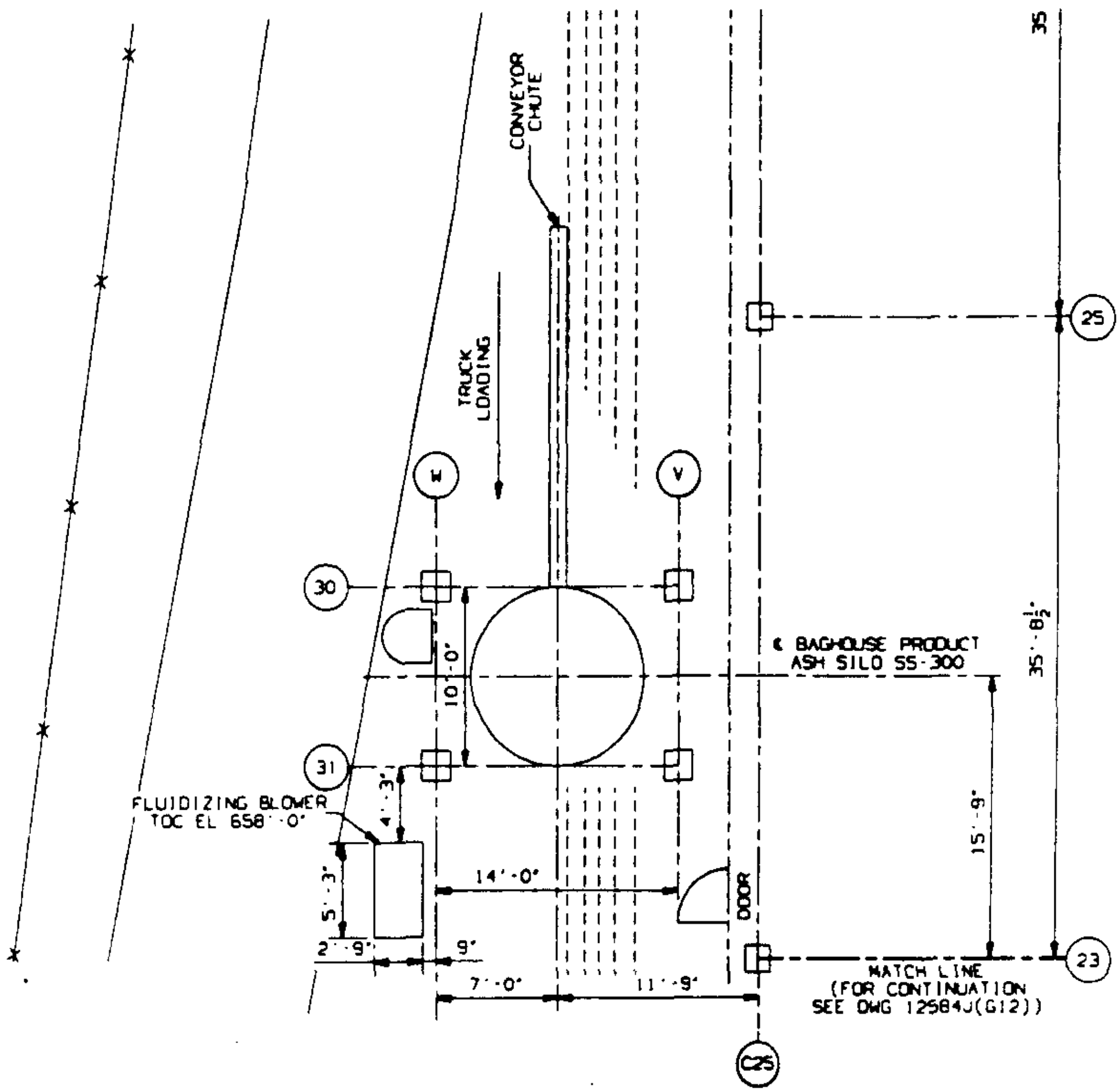

Figure 16. Ash Storage Silo

possible corrosion in the ESP inlet fluework. The design details for the outlet flue gas cooler system are summarized in Table 12. The integration of the outlet flue gas cooler into the facility is illustrated in Figure 17.

Flue Gas Analyzer System

The flue gas analyzer system consists of three independent gas analyzer trains to continuously monitor and record the SO_2, NO_x, and O_2 concentrations in the flue gas at the system inlet, the inlet to the baghouse and the baghouse outlet. The components of the analyzer system are summarized in Table 13.

Data Acquisition System

The data acquisition system is designed to provide for on-line monitoring of key process performance parameters and to permit collection and recording of all measured temperatures and pressures on demand. The components of the data acquisition system are summarized in Table 14.

TABLE 12

OUTLET GAS COOLER SYSTEM

SYSTEM SUPPLIER	NORTH ATLANTIC TECHNOLOGIES
MAJOR COMPONENTS	INLET BLOCK - CARBON STEEL INTERMEDIATE BLOCK 2 - C.S. INTERMEDIATE BLOCK 3 - CORTEN OUTLET BLOCK - 304 S.S. COOLING AIR FAN COOLING AIR DUCTS COOLING AIR CONTROL DAMPER COLD BLOCK WATER WASH SUPPORTS/PLATFORMS
DESIGN CRITERIA	
GAS FLOW	54,552 lb/hr @ FULL LOAD
INLET GAS TEMPERATURE	810 F
OUTLET GAS TEMPERATURE	170 F
COOLING AIR FLOW	115,000 lb/hr
INLET AIR TEMPERATURE	95 F
OUTLET AIR TEMPERATURE	420 F
PRESSURE DROP	3.4
HEAT EXCHANGED	9.2 MMBtu/hr
HEAT TRANSFER SURFACE	11,716 ft2
GAS VELOCITY	36 ft/sec
GAS RESIDENCE TIME	0.84 seconds
HEAT TRANSFER CHARACTERISTICS	
OVERALL TRANSFER COEFFICIENT	4.6 Btu/hr-ft2-F
MINIMUM GAS OUTLET TEMPERATURE	170 F
MINIMUM COOLING AIR INLET TEMP.	95 F (MAINTAINED BY AIR LOOP)
HEAT TRANSFER RANGE	10.1 - 4.3 MMBtu/hr

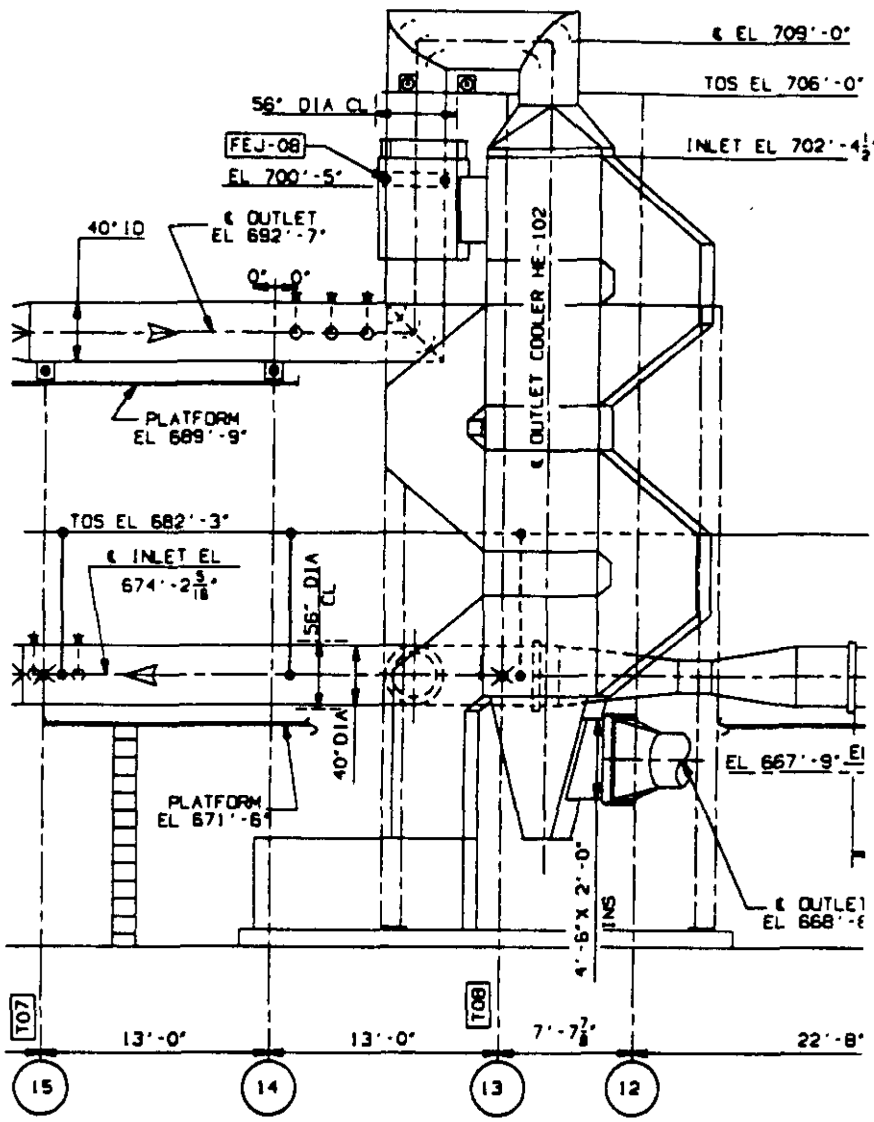

Figure 17. Outlet Flue Gas Cooler

TABLE 13

FLUE GAS ANALYZER SYSTEMS

SYSTEM SUPPLIER	BABCOCK & WILCOX
COMPONENTS OF EACH SYSTEM (3)	SO2 ANALYZER - ANARAD NOx ANALYZER - TECO O2 ANALYZERS - TELEDYNE CHART RECORDER - CHESSELL DIGITAL VOLT METER - FLUKE CHILLER - BAKER DRYER CABINET ENCLOSURE SAMPLE PUMP SAMPLING PROBE HEATED SAMPLE HOSE CALIBRATION GAS
DESIGN CRITERIA	
SAMPLE GAS FLOW	3 - 4 liters/min
GAS TEMPERATURE	120 - 200 F
GAS PRESSURE	3 - 12 inches water
FLUE GAS COMPOSITION	
SO_2	500 - 2500 ppm
NO_x	500 - 800 ppm
NH_3	0 - 500 ppm
O_2	3 - 8 %
CO_2	13 - 18 %
H_2O	6 - 12 %
COMMUNICATION	
BAILEY NETWORK 90	4 - 20 mA DC
DIGITAL VOLT METERS	1 - 5 V DC
CHART RECORDERS	1 - 5 V DC

TABLE 14

DATA ACQUISITION SYSTEM

SYSTEM SUPPLIER	BABCOCK & WILCOX
MAJOR COMPONENTS	GATEWAY 2000 486 DX/50 COMPUTER SERIAL COMMUNICATIONS PORT SERIAL COMMUNICATIONS CABLE BAILEY SOFTWARE INTERFACE DISPLAY SOFTWARE CALCULATION SOFTWARE
DESIGN CRITERIA	
RATE OF ACQUISITION	VARIABLE 1 - 10 min PER SCAN
NUMBER OF CHANNELS	64
HARDWARE	
CPU	33 MHz 80486
MEMORY	4 MB RAM 80 MB HARD DRIVE 1.2 MB FLOPPY DRIVE 1.44 MB FLOPPY DRIVE
COMMUNICATION PORTS	1 SERIAL, 1 PARALLEL
INTERFACE CARD	IEEE-488
SOFTWARE	
OPERATOR INTERFACE	MICROSOFT WINDOWS
CONTROL MODULE SOFTWARE	TOOLBOOK
ACQUISITION MODULE SOFTWARE	VISUAL BASIC
DISPLAY MODULE SOFTWARE	EXCEL
FILER MODULE SOFTWARE	TOOLBOOK
FEATURES	
MONITOR/ACQUIRE OPTIONS CONTINUOUS GRAPHICAL DISPLAY SPREADSHEET DATA STORAGE	

3.5 Equipment List

This section contains a tabular summary of the major equipment required for the SNRB Flue Gas Cleanup Demonstration facility. Table 15 contains a brief description of each piece of equipment, an equipment number (when applicable), quantity, size, and vendor. When appropriate, the shipping weight, horsepower, and voltage are also given. Table 16 contains a listing of the electrical equipment (e.g. gas analyzers, flow indicators, etc) required for the demonstration facility. Finally, a listing of the process and control valves for the demonstration facility is given in Table 17.

TABLE 15. 5 MWe SNRB DEMONSTRATION -- MAJOR EQUIPMENT LIST   02-Dec-92   PAGE 1

NO	REV	EQUIPMENT NO.	DESCRIPTION	QUANT	SIZE	SHIP WEIGHT	HP (KW)	VOLTAGE PHASE	MATERIAL BY: B&W	CONTRACTOR
1	1		------ FLUE SYSTEM -------	1		145,320				
2	1		SYSTEM INLET TO PROPANE FIRED GAS HEATER	LOT	36" I.D.				x	
3	1		PROPANE FIRED GAS HEATER TO INLET FLUE GAS COOLER	120 FT	46" & 42" I.D.				x	
4	1		INLET FLUE GAS COOLER TO BAGHOUSE	LOT	40" I.D.					NARCO
5	1		BAGHOUSE TO OUTLET FLUE GAS COOLER	LOT	40" I.D.				x	
6	1		OUTLET FLUE GAS COOLER TO ID FAN	LOT	36" I.D.				x	
7	1		ID FAN TO SYSTEM OUTLET	LOT	36" I.D.				x	
8	1		SYSTEM RECIRCULATION	LOT	36" I.D.					
9	1		------ FLUE GAS FLOW MONITORS ------							
10	1	FE-100	SYSTEM INLET MONITORING VENTURI	1	36" DIA. X 200"	2695				AITKEN
11	1	FE-101	BAGHOUSE INLET MONITORING VENTURI	1	40" DIA. X 219"	3416				AITKEN
12	1		------ STRUCTURAL STEEL AND SUPPORTS ------							
13	1		PIPE RACK SUPPORTS	LOT		15,000			x	
14	1		FLUE SUPPORTS	LOT		33,100			x	
15	1		SYSTEM INLET TIE-IN SUPPORTS	LOT		1600			x	
16	1		SYSTEM OUTLET TIE-IN SUPPOERTS	LOT		1600			x	
17	1		ELECTRICAL BUILDING AND CONTROL ROOM	LOT		31,000			x	
18	1		PLATFORMS, LADDERS, STAIRS	LOT					x	
19	1		------ EXPANSION JOINTS ------							
20	1		INLET FLUE	2	36" DIA				x	
21	1		HEATER OUTLET TO INLET COOLER	2	42" DIA				x	
22	1		INLET GAS COOLER OUTLET	1	2'6" x 6'6"				x	
23	1		OUTLET GAS COOLER INLET	1	5'9" x 5'10"				x	
24	1		OUTLET GAS COOLER OUTLET	1	2'6" x 5'0"				x	
25	1		BAGHOUSE INLET	1	48" x 34"				x	
26	1		BAGHOUSE OUTLET	1	48" x 34"				x	
27	1		I.D. FAN INLET	1	22" x 63"				x	
28	1		I.D. FAN EVASE OUTLET	1	26" x 54"				x	
29	1		RETURN FLUE	3	36" DIA				x	
30	1		RECIRCULATION FLUE	2	36" DIA				x	
31	1		---------- FLUE DAMPERS ----------							
32	1	D-100	INLET ISOLATION DAMPER	1	36" DIA.	400				DDI
33	1	D-104	OUTLET ISOLATION DAMPER	1	36" DIA.	400				DDI
34	1	D-108	RECIRCULATION FLUE ISOLATION DAMPER	1	36" DIA.	300				DDI
35	1	D-103	SYSTEM GAS FLOW CONTROL DAMPER	1	36" DIA.	500				DDI
36	1		---------- FLUE GAS HEATER SYSTEM ----------							
37	1	T-500	LIQUID PROPANE STORAGE TANK	1	106" DIA x 41'	31000				KAY
38	1		LIQUID PROPANE VAPORIZER SKID	1						KAY
39	1	VP-500	LIQUID PROPANE VAPORIZER	1	74" x 22" x 63"	900				KAY
40	1	P-500	LIQUID PROPANE PUMP	1			1	230/1/60		KAY
41	1	ST-500,01	LIQUID PROPANE STRAINER	2						KAY
42	1	HX-500	BURNER ASSEMBLY (INCL. PIPING)	1						ECLIPSE
43	1	FN-500	COMBUSTION AIR FAN	1						ECLIPSE
44	1	D-500	COMBUSTION AIR CONTROL DAMPER	1						ECLIPSE
45	1		FLUE GAS HEATER CONTROL PANEL	1						ECLIPSE
46	1		PROPANE TANK AREA PIPING AND FITTINGS	LOT						KAY
47	1		BURNER INSTRUMENTATION AND VALVES	LOT						ECLIPSE
48	1		PROPANE TRUCK UNLOAD STATION	1						KAY

TABLE 15. 5 MWe SNRB DEMONSTRATION -- MAJOR EQUIPMENT LIST 02-Dec-92 PAGE 2

NO	REV	EQUIPMENT NO.	DESCRIPTION	QUANT	SIZE	SHIP WEIGHT	HP (KW)	VOLTAGE PHASE	MATERIAL BY: B&W	CONTRACTOR
49	1		---------- AMMONIA INJECTION SYSTEM ----------							
50	1		AMMONIA STORAGE SKID	1	16'9" x 5'6"	3760				FERGUSON
51	1	T-400	AMMONIA STORAGE TANK	1	16'2" x 3'8"	INCL				FERGUSON
52	1	VP-400	AMMONIA VAPORIZER	1	2'10" x 16"	INCL	24	480/3/60		FERGUSON
53	1		AMMONIA INJECTION SYSTEM CONTROL PANEL	1		INCL				FERGUSON
54	1		AMMONIA STORAGE SKID PIPING AND FITTINGS	LOT		INCL				FERGUSON
55	1		AMMONIA STORAGE SKID INSTRUMENTATION AND VALVES	LOT		INCL				FERGUSON
56	1		AMMONIA AIR INJECTION BLOWER SKID	1	12.5' x 5.5' x 4.5'	2000				FERGUSON
57	1	BL-400	INJECTION AIR BLOWER	1	40" x 25" x 25.5"		7.5	460/3/60		FERGUSON
58	1		INJECTION AIR BLOWER INLET FILTER	1						FERGUSON
59	1		INJECTION AIR SKID PIPING AND FITTINGS	LOT						FERGUSON
60	1		INJECTION AIR SKID INSTRUMENTATION AND VALVES	LOT						FERGUSON
61	1		AMMONIA/AIR FLOW CONTROLLER	1						FERGUSON
62	1		AMMONIA/AIR STATIC MIXER	1						FERGUSON
63	1		AMMONIA UNLOADING SYSTEM	1						FERGUSON
64	1		AMMONIA INJECTORS	3	1.5" DIA x 44"					FERGUSON
65	1	HE-101	---------- INLET GAS COOLER ----------							
66	1		INLET COOLER BLOCK	2	6'6" x 5'8" x 4'6"	21000			NAT	
67	1		INLET COOLER HOPPER	1	6'4" x 8'0"	1925			NAT	
68	1	FN-101	COOLING AIR FAN WITH INLET VANES	1	57" x 24" x 51"	1300	15	460/3/60	NAT	
69	1		COOLING AIR PLENUM	1		1800			NAT	
70	1		COOLING AIR DUCTS	LOT	2'6" x 2'0"	3650			NAT	
71	1	XJ-101	COOLING AIR DUCT EXPANSION JOINT	1	2'6" x 2'0"				NAT	
72	1		STRUCTURAL STEEL AND PLATFORM	LOT		9500			NAT	
73	1	BH-600	---------- BAGHOUSE ----------							
74	1		BAGHOUSE MODULE	6	6' x 5' x 30.5'					AMEREX
75	1		INLET PLENUM	1	26" x 42" x 20'					AMEREX
76	1		OUTLET PLENUM	1	26" x 42" x 20'					AMEREX
77	1		BYPASS PLENUM	1						AMEREX
78	1		BAGHOUSE MODULE INLET DAMPERS	12	32" x 12"					AMEREX
79	1		BAGHOUSE MODULE OUTLET DAMPERS	1	32" x 12"					AMEREX
80	1		BYPASS DAMPER	1						AMEREX
81	1		PULSE AIR CLEANING SYSTEM	1						AMEREX
82	1		MODULE INLET EXPANSION JOINTS	6						AMEREX
83	1		MODULE OUTLET EXPANSION JOINTS	6						AMEREX
84	1		BYPASS PLENUM EXPANSION JOINT	1						AMEREX
85	1		HOPPER HEATER SYSTEM	1						AMEREX
86	1		MODULE INSULATION AND LAGGING - SHOP	1						AMEREX
87	1		BAG RETAINERS	LOT					x	
88	1		CATALYST RETAINERS	LOT					x	
89	1		CERAMIC BAGS	LOT						3M
90	1		CATALYST	LOT						NORTON
91	1		PENTHOUSE ENCLOSURE	1	22' x 20' x 23.5'					AMEREX
92	1		MONORAIL/HOIST SYSTEM	1						AMEREX
93	1		BAGHOUSE CONTROL PANEL	1						AMEREX
94	1		SUPPORT STEEL, PLATFORMS, LADDERS, STAIRWAYS	1						AMEREX
95	1		PULSE AIR CLEANING SYSTEM INSTRUMENTATION AND VALVES	1						AMEREX
96	1		HOPPER LEVEL INDICATORS	6						AMEREX
97	1		BAGHOUSE INSTRUMENTATION AND VALVES	LOT						AMEREX

TABLE 15 5 MWe SNRB DEMONSTRATION -- MAJOR EQUIPMENT LIST 02-Dec-92 PAGE 3

NO	REV	EQUIPMENT NO.	DESCRIPTION	QUANT	SIZE	SHIP WEIGHT	HP (KW)	VOLTAGE PHASE	MATERIAL BY B&W	CONTRACTOR
98	1	HE-102	---------- OUTLET GAS COOLER ----------							
99	1		OUTLET COOLER BLOCK	4	6'6" x 5'1" x 5'8"	46000				NAT
100	1		OUTLET COOLER HOPPER	1	6'6" x 8'	1700				NAT
101	1	FN-102	COOLING AIR FAN WITH INLET VANES	1	62" x 32" x 69"	2620	75	460/3/60		NAT
102	1		COOLING AIR PLENUM	1		1600				NAT
103	1		COOLING AIR DUCTS	LOT	2'8"x3'7"& 1'8"x3'11"	10000				NAT
104	1	D-105	OUTLET AIR RECIRCULATION CONTROL DIVERTER VALVE	1						NAT
105	1	XJ-102	AIR INLET DUCT EXPANSION JOINT	1	2'8" x 3'7"					NAT
106	1	XJ-103	RECIRCULATION DUCT EXPANSION JOINT	1	1'8" x 3'11"					NAT
107	1		WATER WASH SYSTEM	1						NAT
108	1		STRUCTURAL STEEL AND PLATFORM	LOT		20500				NAT
109	1		---------- BOOSTER FAN ----------		109" x 115" x 99"	6670	100	460/3/60		
110	1	FN-100	INDUCED DRAFT BOOSTER FAN	1		INCL				ZURN
111	1		FAN INLET BOX	1		INCL				ZURN
112	1		EVASE	1		INCL				ZURN
113	1		FAN CONTROL PANEL	1		INCL				ZURN
114	1		---------- BAGHOUSE ASH REMOVAL SYSTEM ----------							
115	1	F-301	NUVA FEEDER ASSEMBLY	6		9000				UCC
116	1		NUVA FEEDER ISOLATION KNIFEGATE VALVES	12		9000				UCC
117	1		BAGHOUSE ASH TRANSPORT BLOWER SKID	1						UCC
118	1	BL-300	BAGHOUSE ASH TRANSPORT BLOWER	1	7.5' x 2.2' x 8.8'	925	15	460/3/60		UCC
119	1		ASH TRANSPORT BLOWER INLET FILTER	1		INCL				UCC
120	1		ASH TRANSPORT BLOWER DISCHARGE SILENCER	1		INCL				UCC
121	1		ASH TRANSPORT PIPING AND FITTINGS	150 FT						UCC
122	1		ASH TRANSPORT INSTRUMENTATION AND VALVES	LOT						UCC
123	1	SS-300	BAGHOUSE ASH SILO	1	14' x 10' x 33'	23300				UCC
124	1	FL-300	BAGHOUSE ASH SILO DUST COLLECTOR	1		1300				UCC
125	1	FN-300	BAGHOUSE ASH SILO EXHAUST FAN	1		INCL				UCC
126	1	FX-300	BAGHOUSE ASH SILO AIR SLIDE	1						UCC
127	1		BAGHOUSE ASH SILO AIR SLIDE DISCHARGE PORT ISOLATION KNIFEGATE	3		360				UCC
128	1	FR-300	BAGHOUSE ASH SILO ROTARY FEEDER	1		440				UCC
129	1		BAGHOUSE ASH SILO INSTRUMENTATION AND VALVES	LOT		INCL				UCC
130	1		BAGHOUSE ASH SILO STRUCTURAL STEEL, LADDERS	LOT		INCL				UCC
131	1		ASH SILO FLUIDIZERS	4		120				UCC
132	1		ASH SILO FLUIDIZING BLOWER SKID	1	66.2" x 18.0" x 74.1"	800				UCC
133	1	BL-301	ASH SILO FLUIDIZING BLOWER	1		480	5	460/3/60		UCC
134	1		ASH SILO FLUIDIZING BLOWER INLET SILENCER	1		INCL				UCC
135	1		ASH SILO FLUIDIZING BLOWER OUTLET SILENCER	1		INCL				UCC
136	1		ASH SILO FLUIDIZING BLOWER INLET FILTER	1		INCL				UCC
137	1		ASH SILO FLUIDIZING AIR HEATER	1		320	10			UCC
138	1		ASH SILO FLUIDIZING AIR PIPING AND FITTINGS	50 FT						UCC
139	1		ASH SILO FLUIDIZING AIR INSTRUMENTATION AND VALVES	LOT						UCC
140	1		ASH REMOVAL SYSTEM CONTROL PANELS	2						UCC

TABLE 15 5 MWe SNRB DEMONSTRATION -- MAJOR EQUIPMENT LIST 02-Dec-92 PAGE 4

NO	REV	EQUIPMENT NO.	DESCRIPTION	QUANT	SIZE	SHIP WEIGHT	HP (KW)	VOLTAGE PHASE	MATERIAL BY B&W	CONTRACTOR
141	1		---------- REAGENT FEED SYSTEM ----------							
142	1	SS-200	FRESH REAGENT SILO	1	12' x 36'	15500				SMOOT
143	1	BA-200	FRESH REAGENT SILO BIN ACTIVATOR	1	41" x 72" DIA		1 1/2	460/3/60		SMOOT
144	1	FL-200	FRESH REAGENT SILO DUST COLLECTOR	1	112" x 30" x 30"					SMOOT
145	1	FN-200	FRESH REAGENT SILO EXHAUST FAN	1			3	460/3/60		SMOOT
146	1		SILO SKIRT, LIGHTS, VENTILATION FAN	LOT						SMOOT
147	1	FR-200	ROTARY AIRLOCK	1	23" x 18" x 22"	225	1/2	460/3/60		SMOOT
148	1	FW-200	WEIGHT LOSS FEEDER	1	4' x 5' x 6'	1800	1/2	DC		SMOOT
149	1	FR-201	ROTARY AIRLOCK	1	23" x 18" x 22"	225	1/2	460/3/60		SMOOT
150	1	FH-200	FEEDER INLET HOPPER	1						SMOOT
151	1	FL-201	FEEDER INLET HOPPER DUST COLLECTOR	1						SMOOT
152	1		SILO ISOLATION VALVE	1	10" DIA					SMOOT
153	1		SILO INSTRUMENTATION AND VALVES	LOT						SMOOT
154	1		REAGENT TRANSPORT BLOWER SKID	1	61" x 26" x 80"					SMOOT
155	1	BL-200	REAGENT TRANSPORT BLOWER	1			20	460/3/60		SMOOT
156	1		REAGENT TRANSPORT BLOWER INLET SILENCER	1						SMOOT
157	1		REAGENT TRANSPORT BLOWER INLET FILTER	1						SMOOT
158	1		REAGENT TRANSPORT BLOWER DISCHARGE SILENCER	1						SMOOT
159	1		REAGENT TRANSPORT PIPING AND FITTINGS	460 FT						SMOOT
160	1		REAGENT TRANSPORT INSTRUMENTATION AND VALVES	LOT						SMOOT
161	1		TRUCK UNLOAD PIPING AND FITTINGS	60 FT						SMOOT
162	1		TRUCK UNLOAD INSTRUMENTATION AND VALVES	LOT						SMOOT
163	1		TRUCK UNLOAD CONTROL PANEL	1						SMOOT
164	1		REAGENT TRANSPORT CONTROL PANEL	1						SMOOT
165	1		STRUCTURAL STEEL AND LADDERS	LOT						SMOOT
166	1		---------- COMPRESSED AIR SYSTEM ----------							
167	1	AC-900	AIR COMPRESSOR -- PACKAGE	1	52" x 55" x 110"	3500	100	460/3/60		AIR POWER
168	1		RECEIVER TANK SKID	1	78" x 84" x 110"	1600				AIR POWER
169	1	T-901	SERVICE AIR RECEIVER TANK	1	20" x 63"	INCL				AIR POWER
170	1	T-900	INSTRUMENT AIR RECEIVER TANK	1	36" x 96"	INCL				AIR POWER
171	1	AF-901,03	INSTRUMENT AIR FILTER	2	5" x 14"	INCL				AIR POWER
172	1	AD-900	INSTRUMENT AIR DRYER	1	20" x 23" x 75"	INCL				AIR POWER
173	1	AF-902	INSTRUMENT AIR OIL FILTER	1	5" x 23"	INCL				AIR POWER
174	1		RECEIVER TANK SKID PIPING AND FITTINGS	LOT		INCL				AIR POWER
175	1		RECEIVER TANK SKID INSTRUMENTATION AND VALVES	LOT		INCL				AIR POWER
176	1		------- PIPING SYSTEMS -------							
177	1		INSTRUMENT AIR PIPING AND FITTINGS	LOT					x	
178	1		INSTRUMENT AIR INSTRUMENTATION AND VALVES	LOT					x	
179	1		SERVICE AIR PIPING AND FITTINGS	LOT					x	
180	1		SERVICE AIR INSTRUMENTATION AND VALVES	LOT					x	
181	1		SERVICE WATER PIPING AND FITTINGS	LOT					x	
182	1		SERVICE WATER INSTRUMENTATION AND VALVES	LOT					x	
183	1		POTABLE WATER PIPING AND FITTINGS	LOT					x	
184	1		POTABLE WATER INSTRUMENTATION AND VALVES	LOT					x	
185	1		PROPANE VAPORIZER TO BURNER ASSEMBLY PIPING & FITTINGS	LOT					x	
186	1		AMMONIA TANK TO AIR MIXING SKID PIPING AND FITTINGS	LOT					x	
187	1		AMMONIA MIX STATION TO INJECTORS	LOT					x	

TABLE 16: 5 MWe SNRB DEMONSTRATION -- INSTRUMENT LIST 02-Dec-92 PAGE 1

ITEM NO.	TAG NUMBER	DESCRIPTION	SUPPLIED BY	P&ID DRAWING NUMBER	NORMAL OPERATING POINT	PROCESS OPERATING RANGE	MANUFACTURER	MODEL NUMBER	INSTRUMENT RANGE
		---- SYSTEM INLET TO INLET FLUE GAS COOLER ----							
1	AU-100(A)	SYSTEM INLET SO2 ANALYZER	B&W	416975E	3000 PPM	0-3000 PPM	ANARAD	AR-440	0-5000 PPM
2	AU-100(B)	SYSTEM INLET O2 ANALYZER	B&W	416975E	3%	0-10%	TELEDYNE	326RAX	0-25%
3	AU-100(C)	SYSTEM INLET NOX ANALYZER	B&W	416975E	610 PPM	0-900 PPM	TECO	10AR	0-10000 PPM
4	PT-100	SYSTEM INLET GAS PRESSURE TRANSMITTER	B&W	416975E	-8.3"WG	-13to-5inWG	ROSEMOUNT	1151GP3E12B1	-13to-5inWG
5	TE-100	SYSTEM INLET GAS TEMPERATURE	B&W	416975E	650 F	600-700 F	RAM SENSORS	250-K-304-I-26"-0-1K(CI-4)	400-1000 F
6	FT-100	SYSTEM INLET GAS FLOW	B&W	416975E	7.6inWG	0-12.0inWG	ROSEMOUNT	1151DP3E12B1	0-12inWG
7	TE-101(A-D)	FLUE GAS HEATER OUTLET GAS TEMPERATURE	B&W	416975E	1100 F	600-1250 F	RAM SENSORS	CI-1-TB-200/TB-2521	400-1400 F
8	TE-115	REAGENT INJECTION TEMPERATURE -POINT A	B&W	416975E	1000 F	600-1200 F	RAM SENSORS	250-K-304-I-34"-0-1K(CI-4)	400-1400 F
9	TE-116	REAGENT INJECTION TEMPERATURE -POINT B	B&W	416975E	1000 F	600-1200 F	RAM SENSORS	250-K-304-I-34"-0-1K(CI-4)	400-1400 F
10	TE-117	REAGENT INJECTION TEMPERATURE -POINT C	B&W	416975E	1000 F	600-1200 F	RAM SENSORS	250-K-304-I-34"-0-1K(CI-4)	400-1400 F
		----- INLET FLUE GAS COOLER -----							
11	TE-113	BLOCK TEMPERATURE	NA TECH	416976E	vend info	vend info	vendor info	vendor info	vendor info
12	TE-114	BLOCK TEMPERATURE	NA TECH	416976E	vend info	vend info	vendor info	vendor info	vendor info
		----- INLET FLUE GAS COOLER TO BAGHOUSE -----							
13	PT-101	INLET COOLER OUTLET GAS PRESSURE TRANSMITTER	B&W	416976E	-13.5 inWG	-13to-5inWG	ROSEMOUNT	1151GP3E12B1	-13to-5inWG
14	TE-102(A-D)	INLET COOLER OUTLET GAS TEMPERATURE	B&W	416976E	850 F	600-900 F	RAM SENSORS	CI-1-TB-200/TB-2521	400-1200 F
15	AU-101(A)	BAGHOUSE INLET SO2 ANALYZER	B&W	416976E	1800 PPM	0-3000 PPM	ANARAD	AR-440	0-5000 PPM
16	AU-101(B)	BAGHOUSE INLET O2 ANALYZER	B&W	416976E	3% (est)	0-10%	TELEDYNE	326RAX	0-25%
17	AU-101(C)	BAGHOUSE INLET NOX ANALYZER	B&W	416976E	610 PPM	0-900 PPM	TECO	10AR	0-10000 PPM
18	FT-101	BAGHOUSE INLET GAS FLOW	B&W	416976E	7.6 inWG	0-12.0inWG	ROSEMOUNT	1151DP3E12B1	0-12inWG
		----- BAGHOUSE -----							
19	PDT-006	BAGHOUSE DIFFERENTIAL PRESSURE TRANSMITTER	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
20	PS-020	COMPRESSED AIR LINE PRESSURE SWITCH	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
21	PDI-x04	MODULE "x" DIFFERENTIAL PRESSURE INDICATOR	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
22	TE-x06	MODULE "x" OUTLET GAS TEMPERATURE	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
23	TE-x07	MODULE HOPPER "x" TEMPERATURE	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
24	LSH-x08	MODULE HOPPER "x" ASH LEVEL	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
25	TE-008	BAGHOUSE INLET GAS TEMPERATURE	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
26	TIS-007	BAGHOUSE INLET TEMPERATURE SWITCH	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
27	TE-009	BAGHOUSE OUTLET GAS TEMPERATURE	AMEREX	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
		----- BAGHOUSE TO OUTLET FLUE GAS COOLER -----							
28	AU-102(A)	BAGHOUSE OUTLET GAS SO2 ANALYZER	B&W	416976E	1200 PPM	0-2000 PPM	ANARAD	AR-440	0-5000 PPM
29	AU-102(B)	BAGHOUSE OUTLET GAS O2 ANALYZER	B&W	416976E	5% (est)	0-10%	TELEDYNE	326RAX	0-25%
30	AU-102(C)	BAGHOUSE OUTLET GAS NOX ANALYZER	B&W	416976E	81 PPM	0-200 PPM	TECO	10AR	0-10000 PPM
31	AU-104	BAGHOUSE OUTLET GAS AMMONIA ANALYZER		416976E	20 PPM	0-50 PPM	SEVERN SCIENCES	NH3 IN FLUE GAS	VARIABLE
32	OU-801	BAGHOUSE MODULE OUTLET PARTICULATE MONITOR	B&W	416976E	<1% (est)	0-5%	AUBURN INTER.	TRIBOFLOW	LATER
33	OU-802	BAGHOUSE MODULE OUTLET PARTICULATE MONITOR	B&W	416976E	<1% (est)	0-5%	AUBURN INTER.	TRIBOFLOW	LATER
34	OU-803	BAGHOUSE MODULE OUTLET PARTICULATE MONITOR	B&W	416976E	<1% (est)	0-5%	AUBURN INTER.	TRIBOFLOW	LATER
35	OU-804	BAGHOUSE MODULE OUTLET PARTICULATE MONITOR	B&W	416976E	<1% (est)	0-5%	AUBURN INTER.	TRIBOFLOW	LATER
36	OU-805	BAGHOUSE MODULE OUTLET PARTICULATE MONITOR	B&W	416976E	<1% (est)	0-5%	AUBURN INTER.	TRIBOFLOW	LATER
37	OU-806	BAGHOUSE MODULE OUTLET PARTICULATE MONITOR	B&W	416976E	<1% (est)	0-5%	AUBURN INTER.	TRIBOFLOW	LATER
38	OU-800	BAGHOUSE OUTLET OPACITY	B&W	416976E	<1% (est)	0-5%	ENVIROPLAN	CEMOP-281	LATER

TABLE 16: 5 MWe SNRB DEMONSTRATION -- INSTRUMENT LIST 02-Dec-92 PAGE 2

ITEM NO.	TAG NUMBER	DESCRIPTION	SUPPLIED BY	P&ID DRAWING NUMBER	NORMAL OPERATING POINT	PROCESS OPERATING RANGE	MANUFACTURER	MODEL NUMBER	INSTRUMENT RANGE
		----- OUTLET FLUE GAS COOLER -----							
39	TE-109	BLOCK TEMPERATURE	NA TECH	416976E	vend info	vend info	vendor info	vendor info	vendor info
40	TE-110	BLOCK TEMPERATURE	NA TECH	416976E	vend info	vend info	vendor info	vendor info	vendor info
41	TE-111	BLOCK TEMPERATURE	NA TECH	416976E	vend info	vend info	vendor info	vendor info	vendor info
42	TE-112	BLOCK TEMPERATURE	NA TECH	416976E	vend info	vend info	vendor info	vendor info	vendor info
		---- OUTLET FLUE GAS COOLER TO BOOSTER FAN ----							
43	TE-105(A-D)	OUTLET FLUE GAS COOLER OUTLET GAS TEMPERATURE	B&W	416976E	200 F	170-300 F	RAM SENSORS	CI-1-TB-200/TB-2521	100-700 F
44	TE-108	OUTLET GAS COOLER INLET COOLING AIR TEMPERATURE	B&W	416976E	95 F	95 F	RAM SENSORS	250-K-304-I-18"-0-1K(CI-4)	-20 to 150 F
		----- REAGENT FEED SYSTEM -----							
45	LS-200	REAGENT SILO LEVEL INDICATOR - LOW	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
46	LS-201	REAGENT SILO LEVEL INDICATOR - MID	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
47	LS-202	REAGENT SILO LEVEL INDICATOR - HIGH	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
48	PDI-200	REAGENT SILO BIN VENT FILTER DIFF PRESSURE	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
49	PDS-200	SILO BIN VENT FILTER DIFF PRESSURE SWITCH	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
50	LI-204	REAGENT AIRLOCK FEEDER HOPPER LEVEL	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
51	PI-200	REAGENT TRANSPORT BLOWER PRESSURE INDICATOR	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
52	PS-200	REAGENT TRANSPORT BLOWER PRESSURE SWITCH	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
53	TS-200	REAGENT TRANSPORT BLOWER TEMPERATURE SWITCH	SMOOT	416976E	vend info	vend info	vendor info	vendor info	vendor info
		----- FLUE GAS HEATER & PROPANE SUPPLY -----							
54	PI-500	MAIN PROPANE LINE PRESSURE INDICATOR	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
55	PI-501	PILOT PROPANE LINE PRESSURE INDICATOR	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
56	PI-502	SCANNER PURGE AIR LINE PRESSURE INDICATOR	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
57	TS-500	LOW FIRE PROVING SWITCH	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
58	PS-503	SCANNER PURGE AIR PRESSURE SWITCH	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
59	PS-500	BURNER PROPANE INLET PRESSURE SWITCH (LO)	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
60	PS-501	BURNER PROPANE INLET PRESSURE SWITCH (HI)	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
61	PS-502	COMBUSTION AIR PRESSURE SWITCH	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
62	FI-500	PROPANE LOCAL READOUT ROTOMETER	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
63	FE-501	BURNER PROPANE INLET METERING ORIFICE	ECLIPSE	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
64	TE-508	BURNER GAS OUTLET TEMPERATURE - OVERTEMP PROTECT	B&W	VND DWG	1000 F	600-1250 F	RAM SENSORS	#250-K-304-I-34"-0-1K(CI-4)	500-1300 F
65	TE-509	BURNER GAS OUTLET TEMPERATURE - MANUAL CONTROL	B&W	VND DWG	1000 F	600-1250 F	RAM SENSORS	#250-K-304-I-34"-0-1K(CI-4)	500-1300 F
		------- PROPANE SYSTEM -------							
66	PI-503	PROPANE TANK PRESSURE INDICATOR	KAY	VND DWG	vend inf	vend info	MARSHALLTOWN	FIG 5563	0-300 psi
67	LI-500	PROPANE TANK LEVEL INDICATOR	KAY	VND DWG	vend inf	vend info	MAGNETEL	P6342-11-108	vendor info
68	TI-500	PROPANE TANK TEMPERATURE INDICATOR	KAY	VND DWG	vend inf	vend info	FISHER	J701	vendor info
69	LT-501	PROPANE TANK ROTARY GAUGE	KAY	VND DWG	vend inf	vend info	REGO	A9091-18LX	vendor info
70	PI-504	LIQUID PROPANE PUMP DISCHARGE PRESSURE	KAY	VND DWG	vend inf	vend info	NOSKOK	25.300	0-300 psi

TABLE 16: 5 MWe SNRB DEMONSTRATION -- INSTRUMENT LIST 02-Dec-92 PAGE 3

ITEM NO.	TAG NUMBER	DESCRIPTION	SUPPLIED BY	P&ID DRAWING NUMBER	NORMAL OPERATING POINT	PROCESS OPERATING RANGE	MANUFACTURER	MODEL NUMBER	INSTRUMENT RANGE
		----- AMMONIA INJECTION SYSTEM -----							
71	PI-400	AMMONIA TANK PRESSURE INDICATOR	FERGUSON	VND DWG	vend info	vend info	DANTON	vendor info	0-400 psi
72	LI-400	AMMONIA TANK LEVEL INDICATOR	FERGUSON	VND DWG	vend info	vend info	ROCHESTER	vendor info	0-100%
73	TI-400	AMMONIA TANK TEMPERATURE INDICATOR	FERGUSON	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
74	PS-400	AMMONIA TANK PRESSURE SWITCH	FERGUSON	VND DWG	vend info	vend info	UNITED ELECTRIC	J120 Mod 192	vendor info
75	TS-400	AMMONIA VAPORIZER HEATING ELEMENT TEMP SWITCH	FERGUSON	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
76	PI-404	AMMONIA VAPORIZER PRESSURE INDICATOR	FERGUSON	VND DWG	vend info	vend info	DANTON	vendor info	vendor info
77	PI-401	INSTRUMENT AIR PRESSURE INDICATOR	FERGUSON	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
78	PI-402	AMMONIA VAPOR PRESSURE INDICATOR	FERGUSON	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
79	PI-403	AMMONIA VAPOR PRESSURE INDICATOR	FERGUSON	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
80	FT-400	AMMONIA VAPOR FLOW TRANSMITTER	FERGUSON	VND DWG	vend info	vend info	HOFFER	vendor info	vendor info
81	FS-1	AMMONIA FLOW SWITCH	FERGUSON	VND DWG	vend info	vend info	UNIVERSAL	LLCRPSF5SM2U	vendor info
82	FT-401	INJECTION AIR FLOW TRANSMITTER	FERGUSON	VND DWG	vend info	vend info	DIETERICH	DCR-15	vendor info
83	PI-405	INJECTION AIR BLOWER DISCHARGE PRESSURE	FERGUSON	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
84	TI-401	INJECTION AIR BLOWER DISCHARGE TEMPERATURE	FERGUSON	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
		----- ASH REMOVAL SYSTEM -----							
85	PI-300	TRANSPORT AIR PRESSURE	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
86	TS-300	TRANSPORT AIR BLOWER DISCHARGE TEMP SWITCH	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
87	PDI-300	TRANSPORT AIR BLOWER INLET FILTER DIFF PRESS	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
88	PI-301	ASH SILO FLUIDIZING BLOWER DISCHARGE PRESSURE	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
89	TS-301	ASH SILO FLUID BLOWER DISCHARGE TEMP SWITCH	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
90	PDI-301	ASH SILO FLUID BLOWER INLET FILTER DIFF PRESSURE	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
91	LI-300	ASH SILO ASH LEVEL	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
92	LS-301	ASH SILO HIGH LEVEL INDICATOR	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
93	PI-302	AIR SLIDE PRESSURE INDICATOR	B&W	VND DWG	vend info	0-15 PSIG	ASHCROFT	DURAGAUGE 4 1/2"	0-15 psig
94	TS-302	FLUIDIZING AIR HEATER HIGH TEMPERATURE SWITCH	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
95	TC-303	FLUIDIZING AIR HEATER TEMPERATURE CONTROLLER	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
96	PT-303	NUVA FEEDER PRESSURIZER AIR PRESSURE TRANSMITTER	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
97	PS-304	ASH SILO FLUIDIZING AIR PRESSURE SWITCH	UCC	VND DWG	vend info	vend info	vendor info	vendor info	vendor info
		------- COMPRESSED AIR SYSTEM ---------							
98	PS-901	INSTRUMENT AIR LINE PRESSURE SWITCH	B&W	416092E	100 PSIG	80-110 PSIG	------------	--------------------	0-150 psig
99	PI-902	SERVICE AIR PRESSURE INDICATOR	B&W	416092E	100 PSIG	80-110 PSIG	ASHCROFT	DURAGAUGE 4 1/2"	0-160 psig
100	PI-905	INSTRUMENT AIR PRESSURE INDICATOR	B&W	416092E	100 PSIG	80-110 PSIG	ASHCROFT	DURAGAUGE 4 1/2"	0-160 psig
101	PT-903	BAGHOUSE CLEANING AIR PRESSURE TRANSMITTER	B&W	416093E	80 PSIG	40-100 PSIG	ROSEMOUNT	1151GP7E12B1	0-135 psig
		------- SERVICE WATER SYSTEM -------							
102	PI-800	SERVICE WATER PRESSURE INDICATOR	B&W	416094E	80 PSIG	0-100 PSIG	ASHCROFT	DURAGAUGE 4 1/2"	0-160 psig
		------- POTABLE WATER SYSTEM -------							
103	PI-700	POTABLE WATER PRESSURE INDICATOR	B&W	416094E	80 PSIG	0-100 PSIG	ASHCROFT	DURAGAUGE 4 1/2"	0-160 psig

TABLE 17. 5 MWe SNRB DEMONSTRATION -- VALVE LIST 02-Dec-92 PAGE 1

LINE NO.	ITEM NO.	TAG NO.	REV NO.	A D	SERVICE	TYPE	DESIGN Psig/DegF	FLUID	SUPPLIED BY	MANUF	MODEL	P&ID DWG
1			2		------ AMMONIA STORAGE AND INJECTION SYSTEM ------							
2	1	V-401	2		AMMONIA TANK SAFETY PRESSURE RELIEF	PRESS REL	vendor info	AMMONIA	FERGUSON	REGO	AA3135UA265	VEND DWG
3	2	V-402	2		AMMONIA TANK SAFETY PRESSURE RELIEF	PRESS REL	vendor info	AMMONIA	FERGUSON	REGO	AA3135UA265	VEND DWG
4	3	V-403	2		AMMONIA TANK PRESSURE GAUGE ISOLATION	NEEDLE	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-1000	VEND DWG
5	4	V-404	2		AMMONIA TANK 85% OUTAGE GAUGE	BLEEDER	vendor info	AMMONIA	FERGUSON	REGO	3165F	VEND DWG
6	5	V-405	2		LIQUID FILL EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A954	VEND DWG
7	6	V-406	2		LIQUID FILL SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7509BP	VEND DWG
8	7	V-407	2		VAPOR BALANCE EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-951	VEND DWG
9	8	V-408	2		VAPOR BALANCE SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7507BP	VEND DWG
10	9	V-409	2		AMMONIA TANK PRESSURE SWITCH ROOT	NEEDLE	vendor info	AMMONIA	FERGUSON	REGO	3165F	VEND DWG
11	10	V-410	2		VAPOR TO PROCESS EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-954	VEND DWG
12	11	V-411	2		VAPOR TO PROCESS SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7509BP	VEND DWG
13	12	V-412	2		LIQUID TO VAPORIZER EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-954	VEND DWG
14	13	V-413	2		LIQUID TO VAPORIZER SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7509BP	VEND DWG
15	14	V-414	2		VAPOR RETURN FROM VAPORIZER EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-959	VEND DWG
16	15	V-415	2		VAPOR RETURN FROM VAPORIZER SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A-7513AP	VEND DWG
17	16	V-416	2		TANK DRAIN EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-950	VEND DWG
18	17	V-417	2		TANK DRAIN SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A-7505	VEND DWG
19	18	V-418	2		VAPORIZER PRESSURE RELIEF VALVE	PRESS REL	vendor info	AMMONIA	FERGUSON	REGO	AA3130UA265	VEND DWG
20	19	V-419	2		VAPORIZER LIQUID INLET EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-954	VEND DWG
21	20	V-420	2		VAPORIZER LIQUID INLET SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7509BP	VEND DWG
22	21	V-421	2		VAPORIZER VAPOR EXIT EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-959	VEND DWG
23	22	V-422	2		VAPORIZER VAPOR EXIT SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7513AP	VEND DWG
24	23	V-438	2		VAPORIZER PRESSURE GAUGE ROOT	NEEDLE	vendor info	AMMONIA	FERGUSON	REGO	3165F	VEND DWG
25	24	V-423	2		INSTRUMENT AIR SHUT OFF	BALL	vendor info	AMMONIA	FERGUSON	vend info	vendor information	VEND DWG
26	25	V-424	2		INSTRUMENT AIR FILTER REGULATOR	PRESS REG	vendor info	AMMONIA	FERGUSON	FISHER	67FR	VEND DWG
27	26	V-425	2		AMMONIA VAPOR INLET SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7034P	VEND DWG
28	27	V-426	2		AMMONIA VAPOR OUTLET SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7034P	VEND DWG
29	28	CV-400	2		AMMONIA VAPOR PRESSURE REGULATOR	PRESS REG	vendor info	AMMONIA	FERGUSON	CASHCO	1465	VEND DWG
30	29	V-427	2		AMMONIA VAPOR PRESSURE GAUGE ROOT	NEEDLE	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-1000	VEND DWG
31	30	CV-401	2		AMMONIA VAPOR FLOW CONTROL	WAFER	vendor info	AMMONIA	FERGUSON	BAUMAN	vendor information	VEND DWG
32	31	V-428	2		AMMONIA VAPOR BYPASS SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7505AP	VEND DWG
33	32	V-429	2		AMMONIA VAPOR PRESSURE GAUGE ROOT	NEEDLE	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-1000	VEND DWG
34	33	CV-402	2		AMMONIA INJECTION AIR FLOW CONTROL	WAFER	vendor info	AIR	FERGUSON	BAUMAN	vendor information	VEND DWG
35	34	V-430	2		AMMONIA INJECTION AIR BACKFLOW ISOLATION	CHECK	vendor info	AIR	FERGUSON	SCHWITZER	CP3	VEND DWG
36	35	V-431A-C	2		AMMONIA INJECTOR ISOLATION	vendor info	vendor info	AIR	FERGUSON	vendor info	vendor inforamtion	VEND DWG
37	36	V-437	2		AMMONIA INJ AIR BLOWER DISCH PRESS GAUGE ROOT	NEEDLE	vendor info	AIR	FERGUSON	CONTINENTAL	A-1000	VEND DWG
38	37	V-432	2		AMMONIA TRUCK RACK LIQUID FILL EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-958	VEND DWG
39	38	V-433	2		AMMONIA TRUCK RACK LIQUID FILL PRESSURE RELIEF	PRESS REL	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A402NA	VEND DWG
40	39	V-434	2		AMMONIA TRUCK RACK LIQUID FILL SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7513AR W/ HYDROSTAT	VEND DWG
41	40	V-435	2		AMMONIA TRUCK RACK VAPOR BALANCE SHUT OFF	GLOBE	vendor info	AMMONIA	FERGUSON	REGO	A7507AR W/ HYDROSTAT	VEND DWG
42	41	V-436	2		AMMONIA TRUCK RACK VAPOR BALANCE EXCESS FLOW	CHECK	vendor info	AMMONIA	FERGUSON	CONTINENTAL	A-951	VEND DWG

TABLE 17. 5 MWe SNRB DEMONSTRATION -- VALVE LIST 02-Dec-92 PAGE 2

LINE NO.	ITEM NO.	TAG NO.	REV NO.	A D	SERVICE	TYPE	DESIGN Psig/DegF	FLUID	SUPPLIED BY	MANUF	MODEL	P&ID DWG
43			2		------ BURNER ------							
44	42	V-500	2		PROPANE VAPOR INLET SHUT OFF	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
45	43	V-501	2		MAIN PROPANE LINE VENT	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
46	44	CV-500	2		MAIN PROPANE LINE AUTOMATIC SHUT OFF	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
47	45	CV-501	2		MAIN PROPANE LINE AUTOMATIC SHUT OFF	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
48	46	V-502	2		MAIN PROPANE LINE SHUT OFF	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
49	47	CV-502	2		PROPANE FLOW CONTROL	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
50	48	V-503	2		PROPANE PILOT LINE	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
51	49	V-504	2		PROPANE PILOT LINE PILOT	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
52	50	V-505	2		PROPANE PILOT LINE SHUT OFF	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
53	51	V-506	2		PROPANE PILOT LINE PILOT	vendor info	vendor info	PROPANE	ECLIPSE	vend info	vendor information	VEND DWG
54	52	D-500	2		COMBUSTION AIR CONTROL DAMPER	vendor info	vendor info	AMB AIR	ECLIPSE	vend info	vendor information	VEND DWG
55			2		--- PROPANE STORAGE TANK/VAPORIZER ---							
56	53	V-510	2		PROPANE STORAGE TANK PRESSURE RELIEF	PRESS REL	vendor info	PROPANE	KAY	FISHER	H280-250	VEND DWG
57	54	V-511	2		PROPANE STORAGE TANK PRESSURE RELIEF	PRESS REL	vendor info	PROPANE	KAY	FISHER	H280-250	VEND DWG
58	55	V-512	2		PROPANE TANK VAPOR OUT EXCESS FLOW	CHECK	vendor info	PROPANE	KAY	FISHER	F191	VEND DWG
59	56	V-513	2		PROPANE TANK VAPOR OUT SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-16	VEND DWG
60	57	CV-503	2		PROPANE TANK VAPOR OUT PRESSURE REGULATOR	PRESS REG	vendor info	PROPANE	KAY	FISHER	630	VEND DWG
61	58	V-514	2		PROPANE TANK PRESSURE GAUGE ROOT/VENT	COMB/VENT	vendor info	PROPANE	KAY	FISHER	J415;J400	VEND DWG
62	59	V-515	2		PROPANE TANK LIQUID OUT EXCESS FLOW	CHECK	vendor info	PROPANE	KAY	FISHER	F195	VEND DWG
63	60	V-516	2		PROPANE TANK LIQUID OUT SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-16	VEND DWG
64	61	V-517	2		PROPANE TANK LIQUID IN EXCESS FLOW	CHECK	vendor info	PROPANE	KAY	FISHER	F191	VEND DWG
65	62	V-518	2		PROPANE TANK LIQUID IN SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-16	VEND DWG
66	63	V-519	2		PROPANE TANK VAPOR BALANCE EXCESS FLOW	CHECK	vendor info	PROPANE	KAY	FISHER	F191	VEND DWG
67	64	V-520	2		PROPANE TANK VAPOR BALANCE SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-16	VEND DWG
68	65	V-521	2		PROPANE PUMP INLET LINE VENT	RELIEF	vendor info	PROPANE	KAY	FISHER	H-124	VEND DWG
69	66	V-522	2		PROPANE PUMP OUTLET BYPASS VALVE	RELIEF	vendor info	PROPANE	KAY	CORKEN	B166	VEND DWG
70	67	V-523	2		PROPANE PUMP OUTLET BYPASS LINE SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-08	VEND DWG
71	68	V-524	2		PROPANE PUMP OUTLET LINE SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-08	VEND DWG
72	69	V-525	2		PROPANE PUMP BYPASS LINE SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-16	VEND DWG
73	70	V-526	2		PROPANE PUMP OUTLET LIQUID RETURN BACKFLOW ISOLATION	CHECK	vendor info	PROPANE	KAY	POWELL	#563	VEND DWG
74	71	V-527	2		PROPANE TANK VAPOR LINE SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-16	VEND DWG
75	72	V-528	2		PROPANE TANK VAPOR LINE RELIEF	DIAPHRAGM	vendor info	PROPANE	KAY	FISHER	1805-1/13	VEND DWG
76	73	V-529	2		PROPANE VAPORIZER LIQUID INLET SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-08	VEND DWG
77	74	V-530	2		PROPANE VAPORIZER VAPOR OUTLET REGULATOR ISOLATION	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-16	VEND DWG
78	75	CV-504	2		PROPANE VAPORIZER VAPOR OUTLET PRESSURE REGULATOR	PRESS REG	vendor info	PROPANE	KAY	FISHER	630	VEND DWG
79	76	V-531	2		PROPANE VAPORIZER OUTLET REGULATOR ISOLATION	GLOBE	vendor info	PROPANE	KAY	FISHER	N31--16	VEND DWG
80	77	V-532	2		PROPANE TRUCK RACK LIQUID IN BACKFLOW ISOLATION	CHECK	vendor info	PROPANE	KAY	FISHER	G200-16	VEND DWG
81	78	V-533	2		PROPANE TRUCK RACK LIQUID IN SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N310-16	VEND DWG
82	79	V-534	2		PROPANE TRUCK RACK VAPOR BALANCE SHUT OFF	GLOBE	vendor info	PROPANE	KAY	FISHER	N550-10	VEND DWG
83	80	V-535	2		PROPANE TRUCK RACK VAPOR BALANCE EXCESS FLOW	CHECK	vendor info	PROPANE	KAY	FISHER	F105	VEND DWG
84	81	V-536	2		LIQUID PROPANE PUMP PRESSURE GAUGE ROOT	BALL	vendor info	PROPANE	KAY	WORCESTER	444TSE	VEND DWG
85	82	V-537	2		STRAINER ISOLATION	BALL	vendor info	PROPANE	KAY	WORCESTER	444TSE	VEND DWG
86	83	V-538	2		STRAINER ISOLATION	BALL	vendor info	PROPANE	KAY	WORCESTER	444TSE	VEND DWG
87	84	V-539	2		LIQUID PROPANE PUMP ISOLATION	BALL	vendor info	PROPANE	KAY	NIBCO	T-595-CS-R-25	VEND DWG

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LINE NO	ITEM NO.	TAG NO.	REV NO.	A D	SERVICE	TYPE	DESIGN Psig/DegF	FLUID	SUPPLIED BY	MANUF	MODEL	P&ID DWG
					--- PROPANE STORAGE TANK/VAPORIZER cont. ---							
88	85	V-540	2		LIQUID IN SHUT OFF	NEEDLE	vendor info	PROPANE	KAY	BERQUIST	No. 211	VEND DWG
89	86	V-541	2		HYDROSTATIC RELIEF	RELIEF	vendor info	PROPANE	KAY	FISHER	H124	VEND DWG
90			2		------- ASH REMOVAL SYSTEM --------							
91	88	V-300	2		TRANSPORT AIR LINE BACKFLOW CHECK	CHECK	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
92	89	V-301	2		TRANSPORT AIR LINE PLUG VALVE	PLUG	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
93	90	V-302	2		NUVA FEEDER PRESSURIZE LINE PRESSURE TRANS ROOT	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	VEND DWG
94	91	V-303	2		SILO FLUIDIZING AIR LINE BACKFLOW ISOLATION (4)	CHECK	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
95	92	V-304	2		BAGHOUSE HOPPER OUTLET ISOLATION GATE (6)	KNIFEGATE	vendor info	ASH	UCC	vend info	vendor information	VEND DWG
96	93	V-305	2		TRANSPORT AIR BLOWER PRESSURE RELIEF	PRESS REL	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
97	94	V-306	2		TRANSPORT AIR BLOWER BACKFLOW ISOLATION	CHECK	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
98	95	V-307	2		ASH SILO FLUIDIZING AIR BLOWER PRESSURE RELIEF	PRESS REL	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
99	96	V-308	2		ASH SILO FLUIDIZING AIR BLOWER BACKFLOW ISOLATION	CHECK	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
100	97	V-309	2		ASH SILO PRESSURE/VACUUM RELIEF	PRESS REL	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
101	98	V-310	2		AIR SLIDE DISCHARGE PORT ISOLATION	KNIFEGATE	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
102	99	V-311	2		SILO FLUIDIZING BLOWER PRESSURE SWITCH ROOT	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	VEND DWG
103	100	V-312	2		AIR SLIDE HEADER ISOLATION	GLOBE	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
104	101	V-313	2		AIR SLIDE HEADER PRESSURE GAUGE ROOT	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	VEND DWG
105	102	V-314	2		AIR SLIDE HEADER BACKFLOW CHECK	CHECK	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
106	103	V-315	2		SILO HOPPER FLUID. AIR HEADER ISOLATION	GATE	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
107	104	V-316	2		SILO HOPPER FLUID. AIR HEADER BACKFLOW CHECK	CHECK	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
108	105	V-317	2		SILO FLOOR FLUID STONES AIR HEADER ISOLATION (4)	GATE	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
109	106	V-318	2		SILO DISCHARGE ISOLATION	KNIFEGATE	vendor info	ASH	UCC	vend info	vendor information	VEND DWG
110	107	V-319	2		AIR SLIDE DIVERTER VALVE	DIVERTER	vendor info	ASH	UCC	vend info	vendor information	VEND DWG
111	108	V-320	2		NUVA FEEDER 4-WAY VALVE (24)	SOLENOID	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
112	109	V-321	2		NUVA FEEDER SPEED CONTROL VALVE (24)	SPEED CONT	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
113	110	V-322	2		NUVA FEEDER OPER. AIR BACKFLOW ISOLATION (6)	CHECK	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
114	111	V-323	2		NUVA FEEDER 2-WAY VENT (12)	VENT	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
115	112	V-324	2		NUVA FEEDER QUICK EXHAUST (12)	EXHAUST	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
116	113	V-325	2		NUVA FEEDER INLET ISOLATION (6)	KNIFEGATE	vendor info	ASH	UCC	vend info	vendor information	VEND DWG
117	114	V-326	2		NUVA FEEDER OUTLET ISOLATION (6)	KNIFEGATE	vendor info	ASH	UCC	vend info	vendor information	VEND DWG
118	115	V-327	2		SILO FLUIDIZING BLOWER BACK PRESSURE REGULATOR	PRESS REG	vendor info	AIR	UCC	vend info	vendor information	VEND DWG
119	116	V-328 A-F	2		NUVA FEEDER VENT LINE ISOLATION	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	VEND DWG
120	117	V-329 A-F	2		NUVA FEEDER PRESSURIZING LINE ISOLATION	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	VEND DWG
119			2		--------REAGENT FEED SYSTEM ----------							
120	118	V-201	2		FRESH REAGENT SILO PRESSURE/VACUUM RELIEF	PRESS REL	vendor info	AIR	SMOOT	vend info	vendor information	416975E
121	119	V-200	2		FRESH REAGENT SILO DISCHARGE ISOLATION	BUTTERFLY	vendor info	REAGENT	SMOOT	vend info	vendor information	416975E
122	120	V-201A-D	2		DIVERTER VALVES (4)	DIVERTER	vendor info	REAG/AIR	SMOOT	SMOOT	A37-B3-C4-D3-E2-F3-G2	416975E
123	121	V-202	2		REAGENT TRANSPORT AIR BLOWER PRESSURE RELIEF	PRESS REL	vendor info	AIR	SMOOT	KUNKLE	337-2	416975E
124	122	V-203	2		REAGENT TRANSPORT AIR BLOWER BACKFLOW ISOLATION	CHECK	vendor info	AIR	SMOOT	AL TECHNO	5002	416975E
125	123	V-204	2		REAGENT TRANSPORT AIR BLOWER PRES GAUGE ROOT	vendor info	vendor info	AIR	SMOOT	vend info	vendor information	416975E

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LINE NO.	ITEM NO.	TAG NO.	REV NO.	A D	SERVICE	TYPE	DESIGN Psig/DegF	FLUID	SUPPLIED BY	MANUF	MODEL	P&ID DWG
126			2		---------- COMPRESSED AIR SYSTEM ----------							
127	124	V-900	2		COMPRESSOR PRESSURE RELIEF	PRESS REL	150/150	AIR	AIR POWER	vend info	vendor information	416992E
128	125	V-901	2		COMPRESSOR CHECK VALVE	CHECK	150/150	AIR	AIR POWER	vend info	vendor information	416992E
129	126	V-902	2		INSTRUMENT AIR RECEIVER TANK PRESSURE RELIEF	PRESS REL	150/150	AIR	AIR POWER	vend info	vendor information	416992E
130	127	V-903	2		SERVICE AIR RECEIVER TANK PRESSURE RELIEF	PRESS REL	150/150	AIR	AIR POWER	vend info	vendor information	416992E
131	128	CV-900	2		INSTRUMENT AIR PRESSURE REGULATOR	PRESS REG	150/150	AIR	B&W	FISHER	95H (60-120 PSI RANGE)	416992E
132	129	CV-901	2		SERVICE AIR PRESSURE REGULATOR	PRESS REG	150/150	AIR	B&W	FISHER	95H (60-120 PSI RANGE)	416992E
133	130	V-904	2		BAGHOUSE CLEANING AIR PRESSURE TRANSMITTER ROOT	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416993E
134	131	V-905	2		INSTRUMENT AIR PRESSURE SWITCH ROOT	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
135	132	V-906	2		INSTRUMENT AIR TANK DRAIN	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
136	133	V-907	2		SERVICE AIR TANK DRAIN	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
137	134	V-908	2		SERVICE AIR TANK ISOLATION	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
138	135	V-909	2		INSTRUMENT AIR TANK ISOLATION	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
139	136	V-910	2		SERVICE AIR HEADER ISOLATION	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
140	137	V-911	2		INSTRUMENT AIR HEADER ISOLATION	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
141	138	V-912	2		SERVICE AIR PRESSURE GAUGE ROOT	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
142	139	V-913	2		INSTRUMENT AIR PRESSURE ROOT	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416992E
143	140	V-914	2		SERVICE AIR HOSE STATION SHUT OFF	NEEDLE	150/150	AIR	B&W	VOGT	9871T	416993E
144	141	V-915	2		SERVICE AIR HOSE STATION SHUT OFF	NEEDLE	150/150	AIR	B&W	VOGT	9871T	416993E
145	142	V-916	2		SERVICE AIR HOSE STATION SHUT OFF	NEEDLE	150/150	AIR	B&W	VOGT	9871T	416993E
146	143	V-917	2		SERVICE AIR HOSE STATION SHUT OFF	NEEDLE	150/150	AIR	B&W	VOGT	9871T	416993E
147	144	V-918	2		REAGENT SILO HEADER SHUT OFF	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416993E
148	145	V-919	2		BAGHOUSE HEADER SHUT OFF	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416993E
149	146	V-920	2		OUTLET COOLER HEADER SHUT OFF	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416993E
150	147	V-921	2		AMMONIA SKID HEADER SHUT OFF	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416993E
151	148	V-922	2		INLET COOLER HEADER SHUT OFF	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416993E
152	149	V-923	2		SCANNER AIR HEADER SHUT OFF	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416993E
153	150	V-924	2		ASH SILO AIR SHUT OFF	BALL	150/150	AIR	B&W	MARWIN	#823 RTT-S	416993E
154	151	V-925	2		ASH SILO LEVEL INDICATOR COOLING AIR PRESSURE REDUCER	GLOBE	150/150	AIR	B&W	VOGT	12141	416993E
155			2		-------- SERVICE WATER --------							
156	152	V-600	2		TERMINAL POINT SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
157	153	V-604	2		BAGHOUSE AREA HOSE STATION SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
158	154	V-601	2		REAGENT SILO AREA HOSE STATION SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
159	155	V-603	2		ASH SILO AREA HOSE STATION SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
160	156	V-602	2		ASH SILO AREA ASH WETTING NOZZLES SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
161	157	V-607	2		AMMONIA TANK AREA HOSE STATION SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
162	158	V-608	2		INLET COOLER AREA HOSE STATION SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
163	159	V-605	2		OUTLET COOLER COLD BLOCK WASH SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
164	160	V-606	2		SERVICE WATER DRAIN SHUT OFF	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
165	161	V-609	2		SERVICE WATER PRESSURE GAUGE ROOT	BALL	150/150	RW	B&W	MARWIN	#823 RTT-S	416994E
166	162	CV-600	2		SERVICE WATER PRESSURE REGULATOR	PRESS REG	150/150	RW	B&W	FISHER	92W w/6492H (25-75 PSI)	416994E

TABLE 17. 5 MWe SNRB DEMONSTRATION -- VALVE LIST 02-Dec-92 PAGE 5

LINE NO.	ITEM NO	TAG NO.	REV NO.	A D	SERVICE	TYPE	DESIGN Psig/DegF	FLUID	SUPPLIED BY	MANUF	MODEL	P&ID DWG
167			2		---------- POTABLE WATER ---------							
168	163	V-700	2		TERMINAL POINT SHUT OFF	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E
169	164	V-702	2		AMMONIA AREA EYE WASH/EMERGENCY SHOWER SHUT OFF	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E
170	165	V-703	2		POTABLE WATER PRESSURE GAUGE ROOT	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E
171	166	V-705	2		CONTROL ROOM SINK TAP SHUT OFF	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E
172	167	V-704	2		CONTROL ROOM DRINKING FOUNTAIN SHUT OFF	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E
173	168	V-701	2		SYSTEM BACKFLOW CHECK	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E
174	169	V-706	2		POTABLE WATER DRAIN SHUT OFF	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E
175	170	CV-700	2		POTABLE WATER PRESSURE REGULATOR	PRESS REG	150/150	PW	B&W	FISHER	75A (20-80 PSI)	416994E
176	171	V-707	2		LIME SILO AREA EW/ES SHUT OFF	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E
177	172	V-708	2		ASH SILO AREA EW/ES SHUT OFF	BALL	150/150	PW	B&W	MARWIN	#666 RTT-S	416994E

3.6 Demonstration Facility Construction Cost Summary

Construction activity at the demonstration facility was organized into three primary phases: foundation installation, structural steel erection and installation of the equipment, and electrical/control system installation. The cost to complete each of these phases is summarized in the Table 18. The associated costs for procurement of the equipment and engineering support during the construction activity have also been included.

Table 18. SNRB Demonstration Facility Construction Costs

Cost Component	Cost
Foundation Installation	$124,000
Equipment Procurement	
Purchased Equipment	$2,871,500
Sublet Components	$487,500
Mechanical Erection/Installation	$1,131,400
Electrical/Control Installation	$385,800
Engineering Support	$367,200
Total Facility Construction Cost	**$5,367,600**

REFERENCES

1) Chu, P., Downs, W., and Holmes, A. R., "Sorbent and Ammonia Injection Upstream of a High-Temperature Baghouse," Environmental Progress, Vol. 9, No. 3, August 1990, pp. 149-155.

2) Chu, P., Kudlac, G. A., Wilkinson, J. M., and Corbett, R. W., "Simultaneous SO_x/NO_x/Particulate Removal in a High Temperature Baghouse -- Clean Coal 2 Program Update," AFRC 1991 Spring Meeting on NO_x Control, Developments, and Commercial Applications, March, 1991, Hartford, CT.

3) Kudlac, G. A., Farthing, G. A., Szymanski, T. and Corbett, R. W., "SNRB Catalytic Baghouse Laboratory Pilot Testing," AICHE 1991 Summer National Meeting, August, 1991, Pittsburgh, PA.

TAB 1

5 MWe SNRB DEMONSTRATION FACILITY SYSTEM DESCRIPTION

1.0 GENERAL OVERVIEW

The SOx-NOx-ROx Box (SNRB) process combines the removal of SO_2, NO_x, and particulates in a single unit, a high-temperature baghouse. SO_2 removal is accomplished using either a calcium or sodium based sorbent injected into the flue gas. NO_x removal is accomplished by injecting NH_3 to selectively reduce NO_x in the presence of a non-promoted selective catalytic reduction (SCR) catalyst. Particulate removal is accomplished with high-temperature filter bags. In commercial applications, the choice of sulfur sorbent depends on the site application. An eastern utility plant is likely to use a calcium-based sorbent such as lime because of the raw materials and waste disposal costs associated with sodium-based sorbents. Sodium-based sorbents, which are more reactive than calcium-based sorbents, may be more economical at a western site.

The SNRB Demonstration facility shall utilize a 5 MWe flue gas slip stream from the Ohio Edison R.E. Burger Station Boiler No. 8. The following provides the basic process design criteria as well as the general gas and solid side descriptions for the demonstration facility.

Refer to the process and instrumentation diagrams, drawing numbers 416975 to 416976, for a schematic representation of the system.

1.1 Design Criteria

1.1.1 General

Pilot Size:	5 MW
Nominal Capacity:	47,667 lb/hr 22,785 ACFM @ 650 F, -8.5" H_2O
Plant Location:	Ohio Edison R.E. Burger Station Boiler No. 8 Belmont County, OH
Plant Elevation:	658'0" above MSL

Ambient Conditons:

Temperature, Maximum Dry Bulb:	95 F
Temperature, Minimum Dry Bulb:	-15 F
Barometric Pressure:	29.18 in Hg
Relative Humidity, Minimum:	20 %
Relative Humidity, Maximum:	100 %
Location of Equipment:	Outdoors

1.1.2 Fuel

Type: Eastern Bituminous

Source Analysis	Nominal	Design	Range
Ash	10.94%	11.6%	6.6% to 15.0%
S	2.19%	3.5%	0.6% to 3.5%
H	5.09%	4.4%	3.3% to 5.3%
C	73.02%	65.1%	62.0% to 73.5%
H_2O	5.24%	7.5%	4.0% to 1.9%
N_2	1.62%	1.2%	1.0% to 1.9%
Cl		N.A.	

1.1.3 Flue Gas

Pressure at System Inlet*	-8.5" H_2O
Temperature at System Inlet*	650 F
Pressure at System Outlet*	-15." H_2O

* For typical full load boiler operation

Gas Analysis:
(% by volume for a 5 MWe slip stream based on the design coal at a full load excess air of 18%)

N_2	74.11 %
O_2	2.98 %
CO_2	13.98 %
SO_2	0.28 %
HCl	N.A.
H_2O	8.65 %
Total	100.00 %

1.1.4 Flyash

Analysis (% wt.)	Nominal	Range
SiO_2	47.0%	36.2% to 57.0%
Al_2O_3	22.6%	17.7% to 34.0%
Fe_2O_3	22.8%	4.8% to 34.2%
TiO_2	1.3%	0.48% to 2.40%
CaO	3.0%	0.20% to 5.50%
MgO	1.1%	0.21% to 5.00%
Na_2O	0.3%	0.07% to 1.10%
K_2O	1.9%	0.15% to 5.60%

Particle Size Distribution

3 % less than 2 micron
9 % less than 5 micron
20 % less than 10 micron
48 % less than 20 micron
90 % less than 50 micron
100 % less than 100 micron

1.1.5 Water

1.1.5.1 In-house Water

Source:	Filtered River Water
Uses:	Service Water
Pressure, Maximum:	80 psig
Temperature:	N.A.

Composition:

Calcium:	30 ppm
Magnesium:	9 ppm
Sodium:	20 ppm
Bicarbonate (as $NaHCO_3$):	0.0036 %
Sulfate (as S):	0.008 %
Cl:	19 ppm
Silica (as SiO_2):	0.4 ppm
Iron (as Fe):	0.1 ppm
Manganese (as Mn):	0.03 ppm

pH Range:	7.9
TDS:	185 ppm
TSS:	500 ppm

1.1.5.2 Potable Water

Source:	Deep well water
Uses:	Laboratory, control room, drinking
Pressure, Maximum:	80 psig
Temperature:	N.A.

Composition:

Calcium:	125 ppm
Magnesium:	12 ppm
Sodium:	32 ppm
Bicarbonate (as $NaHCO_3$):	0.0053 %
Sulfate (as S):	0.030 %
Cl:	18 ppm
Silica (as SiO_2):	17 ppm
Iron (as Fe):	0.1 ppm
Manganese (as Mn):	0.05 ppm

pH Range:	7.7
TDS:	595 ppm
TSS:	10 ppm

1.1.6 Sorbent

1.1.6.1 Lime

Composition (by wt)

CaO:	95 %
Inerts:	5 %

Bulk Density

Volumetric:	30 lb/ft^3
Loading:	100 lb/ft^3
Angle of Repose:	40°
Average Particle Size:	5-10 microns

1.1.6.1 Sodium Bicarbonate

Composition (by wt)

$NaHCO_3$	95 %
Inerts:	5 %

Bulk Density

Volumetric:	50 lb/ft^3
Loading:	100 lb/ft^3
Angle of Repose:	40°
Average Particle Size:	10-20 microns

1.1.7 Anhydrous Ammonia

Composition:	NH_3
Molecular Weight:	17 lb/mole
Specific Volume:	23 ft^3/lb
Density, (liquid phase):	38.7 lb/ft^3
Specific Volume:	0.59
Viscosity:	$6.72x10^{-6}$ lb/ft-s

1.1.8 Loading

Seismic Zone:	Zone 1
Basic Wind Speed:	70 mph
Snow Load:	25 lb/ft^3

1.2 Flue Gas Side General Description

A flue gas slip stream from the Burger Station Boiler No. 8 economizer outlet hopper section is the source of the flue gas stream source for the pilot facility.

The flue gas is routed through the system where it is first heated by a propane-fired heater to the proper temperature window for injection of a calcium or sodium based sorbent for SO_2 removal. After sulfur sorbent injection, the gas stream is cooled by a plate-type heat exchanger to the desired temperature for ammonia injection. The ammonia for this NO_x removal step is supplied by a packaged ammonia injection system.

The flue gas then enters the hot catalytic baghouse, where additional SO_2 removal occurs, particulates are removed using high temperature bags, and NO_x is selectively reduced by NH_3 in the presence of a catalyst.

After exiting the baghouse the gas is cooled in a second plate-type heat exchanger, passes through a booster fan, and is recombined with the Burger Station outlet flue gas upstream of the Boiler No. 8 electrostatic precipitator.

1.3 Solids Side General Description

The solids handling portion of the SNRB system consists of two (2) basic systems: the reagent feed system and the ash removal system.

The reagent feed system supplies fresh sorbent in the desired quantity to a pneumatic conveying system that transports the sorbent to one of five (5) injection locations in the flue. Four of these injection locations are between the propane-fired burner and the inlet flue gas cooler. The fifth injection point is located just downstream of the inlet gas cooler and is primarily for testing of sodium bicarbonate reagent.

The ash removal system collects ash from each of the baghouse hoppers and transports it via a pneumatic conveying line to an ash storage silo. The ash silo is equipped for truck removal of the ash. Any ash that drops out into either of the flue gas cooler hoppers is removed manually.

2.0 FLUE GAS SIDE

2.1 Flues

The SNRB Demonstration fluework begins with a slip stream take-off at the economizer outlet of Boiler No. 8. It is constructed of A-36 carbon steel and sized for a nominal gas velocity of 3000 feet per minute. A manually operated butterfly damper (D-100) located at the inlet of the pilot system fluework permits isolation of the SNRB system from the existing facility.

The flues are designed to accomodate a full load slip stream gas flow of 47,667 lb/hr. The flue gas mass flow rate increases slightly throughout the system, primarily as a result of gas heater combustion products and the sorbent and ammonia injection streams.

Instrumentation connections for monitoring inlet gas temperature (TE-100), pressure (PT-100) and composition (AU-100) are located upstream of the inlet venturi tube (FE-100). One set of additional test connections are also provided. The additional connections are 90 degrees apart to allow for a flue traverse.

Downstream of the venturi tube is a tie-in for a recirculation flue. This provides for gas recirculation when the pilot system is in a hot stand-by mode. An isolation damper (D-106) in the recirculation flue prevents gas flow through this section during normal operation.

A propane-fired flue gas heater (HX-500) located on a 90° elbow is used to increase the gas temperature from the boiler economizer outlet temperature (about 650 F) to an approximate range of 900-1250 F. The actual downstream temperature is adjustable over this range to accomodate test matrix conditions. Varying the flue gas temperature at the sorbent injection point will provide data on the effect of flue gas temperature on sorbent utilization and overall SO_2 removal efficiency.

A thermocouple grid connection is located downstream of the flue gas heater for temperature control (TE-101 A,B,C,D). Two additional thermocouple connections (TE-508, TE-509) are located just downstream of the burner for use in the heater control scheme.

The burner chamber and the entire length of the fluework to the inlet flue gas cooler are refractory lined. The burner chamber has an inside diameter greater than that of the flue immediately downstream due to burner requirements. Four injection points for sorbent injection are located along the length of the flue between the burner and the inlet flue gas cooler. These injection ports provide for sorbent residence times of approximately 2 s, 1 s, 600 ms, and 200 ms. Just upstream of each of the latter three injection points are thermocouple connections (TE-115, TE-116, TE-117) which are used to measure the gas temperature at the point of injection.

An ammonia injection port is also located in the refractory lined flue, downstream of the burner control thermocouple grid but upstream of the first sorbent injection point. Gas analyzer connections are provided between the third and fourth injection ports to accomodate an SO_x and O_2 analyzer (AU-103).

The inlet flue gas cooler (HE-101) lowers the gas temperature to the desired level for ammonia injection and baghouse operation, usually around 850 F. The temperature of the gas stream can be varied to accomodate the test matrix conditions. A second venturi tube (FE-101) is located between the inlet flue gas cooler and the baghouse (BH-800) to provide an accurate indication of the gas flow entering the baghouse. Temperature and pressure (PT-101) measurement connections are located between the inlet gas cooler and the venturi. The thermocouple grid (TE-102 A-D) is used for correction of the venturi measurement as well as for control of the inlet cooler cooling air fan. Also located upstream of the venturi is a gas analyzer connection.

The flue between the baghouse inlet venturi and the baghouse contains an ammonia injection port, a sorbent injection port, and a gas analyzer connection for SO_2, NO_x, and O_2 (AU-101). An auxiliary test connection (traverse capable) is provided downstream of the sorbent and ammonia injection ports.

The baghouse is provided with a bypass for protection of the baghouse during start-up and potential upset conditions. Automated dampers at the individual compartment outlets and at the bypass line allow rapid response to upset conditions. Opacity meters (OU-801,2,3,4,5,6) are located at the exit of each of the six baghouse modules to monitor for bag breakage/leaking. Thermocouples located in each module (TE-106,206,306,406, 506,606) are used to monitor for any fires that may occur in the modules.

The flue exiting the baghouse contains a gas analyzer connection SO_2, NO_x, and O_2 (AU-102) for and an auxiliary test connection (traverse capable) before entering the outlet flue gas cooler (HE-102). A thermocouple grid (TE-105 A-D) connection is located in the flue downstream of the outlet flue gas cooler for control of the outlet cooler cooling air fan.

The heat exchanger cooling air inlet temperature must be maintained at a 95° F minimum for cold block protection. A recirculation duct from the cooling air exit to the fan inlet is used to control the inlet temperature. A thermocouple (TE-108) at the cooling air fan discharge is used to control the amount of recirculation needed.

The flue gas exiting the outlet flue gas cooler is routed to the booster fan (FN-100) where the pressure is increased to allow return to the existing Boiler No. 8 flue upstream of the electrostatic precipitator. An auxiliary test connection (traverse capable) is located in the flue between the outlet gas cooler and the fan. An opacity meter (OU-800) is located in the flue to measure the baghouse outlet opacity.

A manually operated butterfly damper (D-104), used for isolation of the pilot system, is located at the tie-in with the Boiler No. 8 flue going to the precipitator. The recirculation flue ties in to the SNRB system main flue upstream of this damper. Due to changes in the flue gas conditions, the flue sizes and design temperatures change throughout the pilot facility. The following lists each section of fluework and the applicable design conditions.

2.1.1 System Inlet Flue

This section of flue extends from the system inlet terminal point to the burner chamber.

Gas Flow Rate:	47,667 lb/hr
Design Pressure:	-35 to +15" H_2O
Design Temperature:	750 F
Operating Pressure:	-8.5" H_2O
Operating Temperature:	650 F
Inside Diameter:	36 inches
Material of Construction:	Carbon Steel
Linings:	None
Insulation:	Yes

2.1.2 Burner Chamber to Inlet Flue Gas Cooler

This section of flue extends from the burner chamber to the inlet flue gas cooler.

Gas Flow Rate:	53,214 lb/hr
Design Pressure:	-35 to +15" H_2O
Design Temperature:	1250 F
Operating Pressure:	-9.5" H_2O
Operating Temperature:	650 -1250 F
Inside Diameter:	42 inches
Material of Construction:	Carbon Steel
Lining:	NARCO - HPX50
Insulation:	Yes

Burner chamber inside diameter is 48 inches.

2.1.3 Inlet Gas Cooler to Outlet Gas Cooler

This section of flue extends from the inlet gas cooler to the outlet gas cooler.

Gas Flow Rate:	53,968 lb/hr
Design Pressure:	-35 to +15" H_2O
Design Temperature:	900 F
Operating Pressure:	-11.5" H_2O
Operating Temperature:	500 - 850 F
Inside Diameter:	40 inches

Material of Construction:	Carbon Steel
Linings:	None
Insulation:	Yes

2.1.4 Outlet Gas Cooler to System Exit Terminal Point

This section of the flue extends from the outlet flue gas cooler to the booster fan and from the booster fan to the system exit terminal point at the Burger Station flue.

Gas Flow Rate:	54,466 lb/hr
Design Pressure:	-35 to +15" H_2O
Design Temperature:	600 F
Operating Pressure:	-30.0 to -15.0" H_2O
Operating Temperature:	170 - 300 F
Inside Diameter:	36 inches
Material of Construction:	Carbon Steel
Linings:	None
Insulation:	Yes

2.1.5 Recirculation Flue

This section of flue extends from just downstream of the system inlet venturi to just upstream of the sytem outlet isolation damper.

Gas Flow Rate:	47,667 lb/hr
Design Pressure:	-35 to +15" H_2O
Design Temperature:	600 F
Operating Pressure:	-30.0 to -15.0" H_2O
Operating Temperature:	500 - 600 F
Inside Diameter:	36 inches
Material of Construction:	Carbon Steel
Linings:	None
Insulation:	Yes

2.2 Dampers

Butterfly dampers are utilized for the isolation of the pilot system from the existing facility, controlling the gas flow through the pilot, and for hot stand-by mode operation.

Manual isolation dampers are located in the pilot system inlet, outlet, and gas recirculation flues. The flow control damper is located downstream of the booster fan discharge. The flow control damper is modulated according to gas flow measured by the system inlet venturi (FE-100).

Dampers included as part of a vendor's scope of supply are detailed with the equipment of which the damper is a part.

2.2.1 Inlet Isolation (D-100)

Quantity:	One
Type:	Butterfly
Size:	36"
Manufacturer:	Damper Design, Inc.
Model Number:	RSH36/OBYU
Design Pressure:	-35" H_2O
Operating Pressure:	-8.3" H_2O
Design Temperature:	750 F
Operating Temperature:	650 F
Leakage at Design Cond.:	0.41%
Actuator:	Dyna-Torque #WA20-30 (Manual)

2.2.2 Outlet Isolation (D-104)

Quantity:	One
Type:	Butterfly
Size:	36"
Manufacturer:	Damper Design, Inc.
Model Number:	RSH36/OBYU
Design Pressure:	-35" H_2O
Operating Pressure:	-15" H_2O
Design Temperature:	750 F
Operating Temperature:	200 F
Leakage at Design Cond.:	0.64%
Actuator:	Dyna-Torque #WA20-30 (Manual)

2.2.3 Recirculation Flue (D-106)

Quantity:	One
Type:	Butterfly
Size:	36"
Manufacturer:	Damper Design, Inc.
Model Number:	RSH36/OBYU
Design Pressure:	-35" H_2O
Operating Pressure:	- 5" H_2O
Design Temperature:	750 F
Operating Temperature:	650 F
Leakage at Design Cond.:	0.20%
Actuator:	Dyna-Torque #WA20-30 (Manual)

2.2.4 System Gas Flow Control Damper (D-103)

Quantity:	One
Type:	Butterfly
Size:	36"
Manufacturer:	Damper Design, Inc.
Model Number:	RSH36/OBYU
Design Pressure:	-35" H_2O
Operating Pressure:	-13" H_2O

Design Temperature:	750 F
Operating Temperature:	200 F
Leakage at Design Cond.:	0.64%
Actuator:	Accord/Sheffer

2.3 Flue Gas Heater (HX-500)

A propane fired flue gas heater is located in a 90° elbow of the flue, downstream of the system inlet venturi tube and upstream of the sorbent injection locations. The flue gas heater is used to heat the gas stream to the desired testing temperature and to maintain the system temperature during short periods of no testing. The heater typically increases the temperature of the flue gas from about 650 F to 1000 - 1250 F.

Gaseous propane is supplied to the burner by an integrated propane storage tank/vaporizer assembly. Liquid propane is pumped from the storage tank to the vaporizer. The vaporized propane is then routed to the burner through the burner's valve train.

In order for the burner to be started, the flue gas flow (from FE-100) must be above a minimum level (in addition to any local vendor permissives). The operating burner will be tripped if the flue gas flow falls below the minimum level. High flue gas temperature as measured by TE-508 will also trip the burner. A control signal is generated by the Net-90 based on deviation of the flue gas temperature (TE-101 (A-D average)) from the set-point. A significant deviation of the flue gas temperature from the set point with alert the operator with an alarm.

The Net-90 control signal is received by the local control panel and directed to the combustion air actuator motor which modulates the combustion air flow. A sensing line downstream of the air butterfly valve is connected to the top of the diaphragm on a ratio regulator to control the flow of the propane. Thus the Net-90 signal controls combustion air flow and provides near "on-ratio" modulation of the burner.

Quantity:	One
Manufacturer:	Eclipse (burner)
Model Number:	1000RM-IRI-NEMA4
Fuel Type:	Propane
Heat Output (BTU/hr):	14.0 MMBTU @ -10 "H_2O press.
Combustion Air Fan HP:	10
Combustion Air Flow:	8625 lb/hr (max)

Propane Storage and Delivery System:

Tank Manufacturer:	Plant Systems Inc.
Fuel Tank Tag No.:	T-500
Fuel Tank Size:	Length 41'0" I.D. 9'0"
Fuel Tank Capacity:	18000 gal
Vaporizer Manufacturer:	Sam Dick Industries
Tag No.:	VP-500
Model No.:	EQ-160
Capacity:	160 gal/hr propane
Propane Pump Manufacturer:	Corken
Tag No.:	P-500
Model No.:	C-12
Motor HP:	1

2.4 Inlet Flue Gas Cooler (HE-101)

A plate-type heat exchanger is used to cool the flue gas before the gas enters the ammonia injection section. The heat exchanger typically cools the gas to a temperature of 800 - 900 F.

A control signal from the Net-90 adjusts the cooling air fan inlet vanes based on the set point and the actual gas outlet temperature (TE-102 (A-D average)). The inlet vanes must be closed to start the cooling air fan and in the event of a fan trip, the inlet vanes will close and an alarm will be sounded. Each block of the inlet cooler has a thermocouple at its midpoint which is wired directly to the Net-90 for data acquisition (TE-113 and TE-114).

Manufacturer:	North Atlantic Technologies
Type:	Plate
Size:	24'10"x18'5"x8'4"
Design Pressure (gas side):	-35" to 15" H_2O
Design Pressure (air side):	6" H_2O
Max. Inlet Gas Temp:	1250 F
Max. Allowable Outlet Gas Temp:	900 F
Min. Air Inlet Temp:	-15 F
Outlet Air Temp (@ design cond):	720 F
Overall U:	4.0 BTU/hr-ft^2-F
Fouling Resistance Used:	0.02
Casing Material:	Carbon Steel
Heat Transfer Surface Area:	4019 ft^2
Heat Transfer Surface Material-	
Cold Block:	Aluminized Steel
Hot Block:	SS304
Cleaning Equipment:	Soot Blower Connections

Cooling Air Fan (FN-101)

Manufacturer:	Buffalo Forge
Model No.:	Aerocline 600
Max/Min Air Flow:	60000/8800 lb/hr
Pressure Increase:	4" H_2O
Brake/Motor HP	12.6/15
Speed:	1800 RPM
Motor Frame Size:	254T

Cooling Air Fan Inlet Vanes (D-101)

Manufacturer:	Buffalo Forge

2.5 Baghouse (BH-800)

The baghouse is designed to operate in a hot flue gas environment, typically in a range from 800 - 900 F. The NO_x reduction catalyst is housed in an assembly within the bags. All baghouse functions are controlled through the vendor local controls. Some of the baghouse operating conditions are transmitted to the Net-90 for data acquistion and informational use.

Hot flue gas entering the baghouse is distributed to each of six compartments through an inlet manifold. Each compartment can be isolated from the inlet manifold by a manually operated butterfly damper. The inlet manifold contains a thermocouple (TE-006) wired directly to the Net-90 for data aquisition purposes and a temperature switch that alarms (on the vendor panel) high and low inlet gas temperature. A high inlet flue gas temperature will trip the baghouse into the bypass mode. The upstream tap of the baghouse differential pressure transmitter (PDT-006) is also located in the inlet manifold. The differential pressure transmitter is used to control pressure difference-based cleaning and is alarmed for high and low values (on the vendor panel). The pressure difference signal is also transmitted to the Net-90 for data acquisition purposes.

Each of the six compartments of the baghouse have individual differential pressure gauges (PDI-x04) for local indication of the module differential pressure. Each compartment also has a thermocouple (TE-x06), wired directly to the Net-90 for data acquisition and fire protection. High temperature in any compartment will cause the Net-90 to send a signal to the vendor panel where an alarm will sound. Outlet opacity meters (OU-80x) are also provided at the exit of each baghouse module to assist in detecting and locating leaking or broken bags.

Each compartment has a heated hopper (temperature indicated by TE-x07) with a level indicator. The hopper heater controls are mounted directly on the hopper. Level indicators have local read-out only. High and low baghouse differential pressure as well as low cleaning air pressure (PS-020) are alarmed locally.

A baghouse trip involves an opening of a poppet damper isolating the bypass flue and the closing of compartment outlet poppet dampers. The flue gas is thus routed directly to the outlet manifold. A signal indicating the baghouse trip is sent to the Net-90. A vendor local interlock of high inlet temperature to the baghouse will cause a trip to the bypass mode.

The outlet manifold is equipped with a thermocouple and the downstream tap of the differential pressure transmitter. The thermocouple is wired directly to the Net-90 for data acquistion purposes.

On-line and off-line cleaning are availible for the baghouse compartments. In addition, the bags may be cleaned manually or in an automatic cycle. In the automatic mode the bag cleaning frequency can be controlled by baghouse pressure differential, timer, or a combined differential pressure/time cycle. The manual mode allows compartments to be cleaned at the operator's discretion.

Manufacturer:	Amerex, Inc.
Size:	19' x 15.5' x 49.3'
Number of Compartments:	6 (3x2)
Design Pressure:	±35" H_2O
Design Temperature:	900 F
Design Gas Flow:	54630 lb/hr
Air to Cloth Ratio -	
All compart. in service:	3.74
One compart. out of service:	4.49
Cleaning air Requirements:	84 SCFM @ 80 psig
Cleaning Type:	Venturi
On-line/Off-line Cleaning:	Both Available
Bags/Compartment:	42 (6x7)
Bag Diameter/Length:	6"/20'
Effective Cloth Area/Bag:	31.75 ft^2
Material of Construction:	Carbon Steel
Thickness:	3/16"
Insulation Material:	Mineral Wool
Insulation Thickness:	4"
Lagging Material/Thickness:	Aluminum/0.032"
Hopper Storage Capacity (ft^3):	37 ft^3
Hopper Heater (kW/hopper):	5 kW/hopper

Compartment Inlet Dampers	
Quantity:	Six
Type:	Butterfly
Size:	20"
Actuator:	Manual, chain wheel

Compartment Outlet Dampers	
Quantity:	Six
Type:	Poppet
Size:	20"
Actuator:	Pneumatic w/ limit switches

Bypass Damper	
Quantity:	One
Type:	Poppet
Size:	32"
Actuator:	Pneumatic w/ limit switches

Expansion Joints	
Quantity:	Twelve
Manufacturer:	Dynex

2.6 Outlet Flue Gas Cooler (HE-102)

A plate-type heat exchanger is used to reduce the flue gas temperature exiting the baghouse. Exit gas temperature from the heat exchanger is in the range of 170 - 300 F.

A control signal from the Net-90 adjusts the cooling air fan inlet vanes based on the set point and the actual gas outlet temperature (TE-105 (A-D average)).

A control signal from the Net-90 adjusts the recirculation diverter valve so a portion of the exhausted cooling air mixes with the inlet cooling air to maintain a minimum inlet temperature. The adjustment is based on the set point temperature and the actual inlet cooling air temperature (TE-108). The minimum allowable cooling air inlet air temperature is 95° F to protect the cold block from operating at potential acid dewpoint temperatures.

The diverter valve and the inlet vanes must be closed for the fan to start and if the fan trips off at any time the dampers will close and an alarm will sound. Thermocouples at the midpoint of each block are wired to the Net-90 for data acquisition (TE-109, TE-110, TE-111, TE-112).

Manufacturer:	North Atlantic Technologies
Type:	Plate
Size:	43'2" x 25'6" x 8'6"
Design Pressure (gas side):	-35" to 15"
Design Pressure (air side):	15"
Max. Inlet Gas Temp:	900 F

Min. Allowable Outlet Gas Temp:	170 F
Min. Inlet Air Temp:	95 F
Air Outlet Temp (@ design cond):	415 F
Overall U:	4.6 BTU/hr-ft^2-F
Fouling Resistance Used:	0.01
Casing Material:	Carbon Steel
Heat Transfer Surface Area:	11716 ft^2
Heat Transfer Surface Material-	
Cold Block:	Corten/SS304
Hot Block:	Carbon Steel
Cleaning Equipment:	Soot blower connection Cold block water wash

Cooling Air Fan (FN-102)

Manufacturer:	Buffalo Forge
Model No.:	Aerocline 805
Max/Min Air Flow:	128500/49000 lb/hr
Pressure Rise:	12"
Brake/Motor HP	72.8/75
Speed:	1417 RPM
Motor Frame Size:	365T

Cooling Air Fan Inlet Vanes (D-102)

Manufacturer:	Buffalo Forge

Recirculation Air Control Damper (D-105)

Type:	Diverter Valve
Manufacturer:	Associated Craftsmen, Inc.

2.7 Booster Fan (FN-100)

The booster fan, located downstream of the outlet gas cooler, is used to compensate for the system gas side pressure losses. It is also used in the hot standby mode to recirculate flue gas through the system during periods of shut-down. The control damper (D-103) must be closed in order for the fan to start. Thirty seconds after the booster fan is started the control damper is released to open and control gas flow. A booster fan trip will initiate a complete SNRB system trip.

Manufacturer:	Zurn Industries
Model No.:	80 RHM 5440 Series
Air Flow @ design cond.:	17131 ACFM
Pressure Incr. @ design cond.:	21.5 " H_2O
Fan Speed:	1775 RPM
Motor HP:	100
Motor Frame Size:	405T

3.0 SOLIDS HANDLING SYSTEMS

3.1 Reagent Feed System

The reagent feed system consists of a storage silo with bin activator, loss-of-weight feeder, and a pneumatic conveying system with blower, valves, rotary air locks, piping, and all instrumentation necessary to transport sorbent at the desired feed rate to the injection points in the flue. The storage silo stores either hydrated lime or sodium bicarbonate sorbent depending on the sorbent being tested at the time.

The fresh reagent flow rate is controlled by a 4-20 mA signal from the Net-90. The flow rate signal is based on demand calculated from the gas flow rate (FE-100), the inlet gas SO_x composition (AI-100A), the pre-set stoichiometric ratio, and the availability of sorbent in the feed stock. The reagent feed system will not operate if the baghouse is in the bypass mode.

The reagent empties from the storage silo to a loss-of-weight feeder (FW-200) when the silo discharge valve (V-200) is opened. The loss-of-weight feeder is equipped with a single bag vent filter to control reagent dust emissions. The feeder discharges solids through a rotary airlock (FR-200) into a feeder hopper. The feeder hopper is equipped with a high level switch and a single bag filter to control reagent dust emissions. If the hopper level is too high an alarm will sound and the loss-of-weight feeder will stop.

A second rotary feeder (FR-201) discharges the reagent into the transport line, from where the reagent is conveyed to the point of injection. Diverter valves (V-201) direct the flow to the desired branch of the system. Zero speed switches alarm stopped airlocks. Feed equipment above the non-functioning airlock will stop.

The reagent silo is provided with a truck unloading station and is sized to hold greater than one standard truck load of material, approximately 35 tons. The silo is equipped with a pulse jet type bin filter (FL-200), vacuum/ pressure relief valve (V-201), and access doors. A differential pressure switch will alarm a plugged bag condition if the high differential pressure exists for more than 30 seconds.

Reagent levels are monitored within the silo by three level switches - high, mid, and low (LS-200, LS-201, LS-202). Each switch lights a light on the local panel to indicate reagent level. In addition, a high level indication will sound an alarm if a fill hose is connected at the truck unloading rack.

The pneumatic conveying system utilizes a positive displacement blower (BL-200) as the air source. The blower is equipped with an inlet filter and silencer, pressure relief valve, pressure gauge, high pressure switch, discharge silencer, and check valve. An AC variable frequency controller allows the speed of the blower to be varied to accomodate different transport air flow rates.

High pressure in the transport system will light an indicating light on the local panel upon initial detection of the high pressure condition. After 2 seconds the rotary airlocks and loss-of-weight feeder will stop and a alarm horn will sound. If the high pressure condition continues for 15 seconds the blower will be shut down.

3.1.1 Reagent Storage Silo (SS-200)

Manufacturer:	Smoot Co.
Reagent Material:	Hydrated lime or sodium bicarb.
Capacity:	70000 lb
Size - Height:	42 ft
Diameter:	12 ft
Materials of Construction:	carbon steel

3.1.2 Reagent Bin Activator (BA-200)

Manufacturer:	Carrier Vibranetics
Model:	BD-6
Size:	6 ft

3.1.3 Fresh Reagent Weigh Feeder (FW-200)

Manufacturer:	Thayer Scale
Type:	Loss-of-weight
Model No.:	LWF-SC-S-10-CS
Capacity:	10 ft^3

3.1.4 Fresh Reagent Rotary Airlocks (FR-200)

Manufacturer:	Smoot Co.
Model No.:	FT9
Quantity:	2
Type:	8 vane, closed end

3.1.5 Reagent Pneumatic Conveying System

Manufacturer:	Smoot Co.
Design Temperature:	70 F
Design Pressure:	5.7 psig
Solids/Air Ratio:	1.7 (max)
Pick-up Velocity:	66.7 ft/s

Discharge Velocity:	92.5 ft/s
Conveying Line Size:	3.5 in O.D.
Conveying Line Material:	carbon steel
Blower Type:	positive displacement
Blower Manufacturer:	Sutorbilt
Model:	6 HL
Blower Motor HP:	20
Additional Equipment:	AC variable frequency controller

3.1.6 Diverter Valves

Quantity:	4
Manufacturer:	Smoot Co.
Model No.:	A37-B3-C4-D3-E2-F3-G2
Type:	Slide
Material:	304SS
Operator:	Pneumatic

3.2 Ash Removal System

The ash removal system transports solids collected in the baghouse hoppers to the baghouse product silo. The baghouse product silo is sized to hold twenty-four (24) hours of ash solids produced at full pilot operation.

Ash is discharged from each of the baghouse module hoppers to the transport line through NUVA feeders. Knifegate valves isolate the NUVA feeder from the hopper and the transport line. In operation, the upper knifegate valve first opens for a set time to allow ash to fill the NUVA feeder bottle, then closes to isolate the feeder. Air displaced by the ash is vented to the baghouse hopper. The feeder vessel is then pressurized to a pressure slightly above the transport line pressure by a separate line taken from the transport blower discharge piping. The lower knifegate valve opens to discharge the solids into the conveying line, then closes. Finally, the feeder vessel is vented to the hopper to allow the cycle to repeat.

The six NUVA feeders are activated one at a time, in sequence, to prevent overloading of the transport line with ash. The cycle is continued until a no load condtion is sensed. Depending on which of two automatic modes of operation is selected, the conveying cycle will either continue or a final transport line purge followed by annunciation of the conveying completion is executed.

The ash is discharged from the storage silo with a rotary feeder and air slide. Three discharge points on the air slide allow the discharge point of the ash to be adjusted. A dedicated blower and heater are provided for the ash silo heated fluidizing system.

The ash removal system operates independently of the rest of the SNRB system. All functions of the ash removal system are controlled by the vendor supplied instumentation. Interface with the Net-90 system extends only to indication of the ash conveying system's operating status.

Manufacturer:	United Conveyor Corp.
Design Temperature:	850 F
Design Pressure:	4.4 psig
Solids/Air Ratio:	1.24
Pick-up Velocity:	63 ft/s
Discharge Velocity:	77 ft/s
Conveying Line Size:	3"
Conveying Line Material:	Sch 80 Carbon Steel

Conveying Air Blower (BL-300)

Manufacturer:	Sutorbilt
Model Number:	5ML-RHC
Size:	7.5' x 2.2' x 8.8'
Capacity:	253 ICFM
Discharge Pressure:	4.4 psig
Discharge Temp. Increase:	64 F
Motor HP:	15
Motor Speed:	1750 RPM
Motor Frame Size:	later

Baghouse Product Storage Silo (SS-300)

Reagent Material:	Baghouse Product Ash
Sizing Density, Volumetric:	30 lb/ft^3
Sizing Density, Structural:	100 lb/ft
Capacity:	30000 lb
Size - Height:	33 ft (total)
Diameter:	10 ft
Materials of Construction:	A-36 Mild Steel

Baghouse Product Silo Fluidizing Blower (BL-301)

Manufacturer:	Sutorbilt
Model Number:	4ML-RHC
Size:	later
Capacity:	170 ICFM
Discharge Pressure:	5 psig
Discharge Temp. Increase:	later
Motor HP:	7.5
Motor Speed:	1750
Motor Frame Size:	later
Heating System kW:	10

4.0 MISCELLANEOUS SYSTEMS

4.1 Ammonia System

A complete, packaged delivery system supplies ammonia vapor to the ammonia injection points in the flue downstream of the inlet flue gas cooler.

The ammonia feed rate is controlled by a signal from the Net-90. The signal is generated based on the flue gas flow rate (FE-101), the NO_x concentration (AI-101C), and the pre-set stoichiometric ratio.

Ammonia flows from the storage tank to the ammonia vaporizer where an electrical resistance heater vaporizes it. The ammonia vapor is then directed into the storage tank headspace to maintain a set pressure. The vapor flow from the tank to the air/ammonia mixer is controlled by a wafer type valve.

Injection air is provided from a fan at a constant air:ammonia ratio of 19:1. Air flow is controlled by the vendor supplied controller, based on the ammonia flow rate desired. Air and ammonia are mixed in a low pressure static mixer before being delivered to the system.

The ammonia system can not be started if there is no flue gas flowing through the SNRB system or if the baghouse is in the bypass mode. A system trip, gas temperature out of range for injection, or low flue gas flow will trip the ammonia system off.

Manufacturer:	Ferguson Industries
Storage Tank Skid Size:	16'9" x 5'6"
Storage Tank Capacity-	
Total Volume:	1000 gal
Liquid Volume:	850 gal
Tank Design Pressure:	250 psig
Tank Design Temperature:	100 F
Vaporizer Capacity:	35 lb/hr
Vaporizer kW:	20
Ammonia Feed Line Size:	1 1/4 "
Ammonia Feed Line Pressure:	2 psig
Ammonia Feed Rate Range:	2-27 lb/hr
Injection Air Pressure:	2 psig
Injection Air Temperature:	later
Injection Air Flow Rate:	1125 lb/hr (max)
Air/Ammonia Ratio:	19
Fan Capacity:	1125 lb/hr
Fan HP:	5

4.2 Compressed Air

A completely packaged compressed air system supplies the instrument and service air requirements of the pilot system, including all cleaning air needed for the baghouse and the silo bin vent filters.

Two receiver tanks are mounted on a common skid. One receiver tank provides instrument air and the second tank provides the service air. Each tank is equipped with a pressure gauge and drain connection. The header from each tank is equipped with a pressure regulator and pressure gauge. In addition, the baghouse branch of the instrument air line is equipped with a pressure transmitter (PT-903) to allow monitoring of the baghouse cleaning air pressure.

The compressed air system operates independently of the rest of the SNRB systems. Control is porvided through the vendor logics. Interfaces with the Net-90 system are restricted to indication of the compressor status with the exception of an alarm for low baghouse cleaning air pressure from PT-903.

Manufacturer:	Ingersoll-Rand
Compressor Type:	Rotary Screw
Model Number:	EP-100 SSR
Design Pressure:	125 psig
Design Inlet Temperature:	95 F
Outlet Temperature (60 F ambient basis):	75 F
Dryer Manufacturer:	Hankison
Dryer Model Number:	DH-60
Dryer Type:	Heatless regenerative
Dryer Capacity:	60 CFM
Filter Manufacturer:	Hankison
Air Filter Model Number:	A-100
Air Filter Capacity:	100 CFM @ 100 psig
Oil Removal Filter Model Number:	C-100
Oil Removal Filter Capacity:	100 CFM @ 100 psig
Receiver Tank Manufacturer:	Roy E. Hanson Jr.
Instrument Air Receiver Capacity:	400 gal
Instrument Air Receiver Size:	36" x 98"
Service Air Receiver Capacity:	80 gal
Service Air Receiver Size:	20" x 63"

4.3 Water System

The service water and potable water are provided by branches routed from existing plant locations. Potable water is provided to the control room, laboratory trailer, and emergency eyewash/shower station located in the ammonia storage area. Service water hose stations are located in the following areas:

- Ammonia Storage
- Reagent and Product Ash Storage
- Baghouse
- Outlet Cooler

Service water is also supplied to the product ash silo discharge point for ash wetting and to the outlet flue gas cooler cold block for flushing.

The existing potable water tank in the southwest corner of the boiler building is the source of potable water for the SNRB system. The pressure (PI-700) is regulated (CV-700) to the rest of the system. The service water source pressure (PI-600) is regulated (CV-600) to the rest of the system.

TAB 2

5 MWe SNRB DEMONSTRATION FACILITY CONTROL SYSTEM DESCRIPTION

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1.0 Scope

This document covers the general process control philosophy and requirements for the 5-MWe SNRB Demonstration facility.

The control system consists of analog control loops for process control, the digital equipment permissives, interlocks and alarms, and the process instrumentation required for indication, control and data acquisition.

The system control requirements, analog and digital, shall be performed by a Network 90 system as provided by the Bailey Equipment Company.

The only equipment referenced in this document is that which has, or is used for, a controlling function or feedback to the control system for control, indication, alarm or data acquisition. No manually operated equipment without feedback to the control system is mentioned herein. Likewise, locally mounted, vendor sub-system, instrumentation is not included in this description. The software requirements, graphic displays, etc., associated with the data acquisition system are also not included.

2.0 Definitions

The following definitions apply to commonly used terms in this document:

Automatic Mode:	When a control loop is in the Automatic Mode the system performs the required functions based on operator adjustable set points. The automatic mode of control includes all supervisory permissives, interlocks, trips and monitoring functions.
Manual Mode:	When the Manual Mode is selected the automatic control based on set point deviation is deactivated. The operator must manually position the final control element to achieve the desired result. All supervisory permissives, interlocks, trips and monitoring functions remain active during the manual mode.
Alarms:	An audible and/or visible signal indicating an off standard or abnormal condition.
Permissive to Start:	The input signal must be proven true for the equipment to be started. Once started, loss of the input signal has no effect on the equipment operation.
Interlocks to Run:	The input signal must be proven true for the equipment to remain in operation once started. Loss of the input signal trips the equipment.
Net-90 Input:	An analog or digital signal sent to the control system from a corresponding instrument, limit switch or local panel output.
Net-90 Output:	An analog or digital signal sent from the control system to a final control element, external recorder or device, or local panel.
CTM:	Configuration and Tuning Module (CTM). Reference Bailey product instructions E93-903.

M/A Station: Manual/Automatic Station. An operator interface station that generates a set point and provides Manual/Automatic transfers, control output adjustment in the Manual Mode, and set point adjustment in the Automatic Mode.

3.0 Operator Interface

The following is a summary of the required operator interfaces with the Network 90 control system:

Inlet Gas Flow - M/A Station

Manual/Automatic Select

Pilot Inlet Gas Flow Set Point

Pilot Flue Gas Flow Control Damper Position - Throttling 0 to 100% open.

Flue Gas Heater - M/A Station

Manual/Automatic Select

Flue Gas Temperature Set Point

Burner Control - Throttling 0 to 100%

Fresh Reagent Feed - M/A Station

Manual/Automatic Select

Fresh Reagent Feed Rate

Ammonia Injection - M/A Station

Manual/Automatic Select

Ammonia Injection Rate

Available Sorbent in Fresh Reagent - Wt % - via CTM

Sorbent Injection Stoichiometric Ratio - via CTM

Ammonia Injection Stoichiometric Ratio - via CTM

Inlet Flue Gas Cooler - M/A Station

Manual/Automatic Select

Cooler Outlet Flue Gas Temperature Setpoint

Inlet Flue Gas Cooler - Cooling Air Inlet
Vanes Position - Throttling 0 to 100% open.

Outlet Flue Gas Cooler - M/A Station

Manual/Automatic Select

Outlet Flue Gas Temperature Set Point

Outlet Flue Gas Cooler - Cooling Air Inlet
Vanes Position - Throttling 0 to 100% open.

Outlet Gas Cooler Cooling Air Recirc - M/A Station

Manual/Automatic Select

Inlet Cooling Air Temperature Set Point

Outlet Flue Gas Cooler - Cooling Air
Recirculation Diverter Valve Position -
Throttling 0 to 100% Open

System Trip Command

Baghouse Trip to Bypass Mode

valve to maintain the inlet cooling air temperature based on deviation from an operator adjusted set point.

Manual Mode: The operator manually adjusts the cooling air recirculation damper based on the temperature indication provided by the inlet cooling air temperature thermocouple (TE-108).

4.5 Ammonia Injection System

The ammonia injection system is a complete, packaged system with all the local controls necessary to provide the ammonia flow required across the system load range and test conditions.

All controls required for the ammonia storage, supply and dilution air are part of the vendor scope of supply.

The vendor control panel receives a 4-20 mA Network 90 output signal to vary the amount of ammonia delivered to the injection point. This signal is generated by maintaining the desired stoichiometric ratio (moles NH_3 per mole of NOx) using a function generator. Inputs to the function generator are the corrected flue gas flow determined from (FT-101) and the NOx concentration as indicated by the the flue gas analyzer (AI-101C).

The vendor local panel provides ammonia and dilution air flow rate signals to the Net-90 for control feedback, indication and data acquisition.

Automatic Mode: The Network 90 automatically adjusts the 4-20 mA output signal based on the error between the ammonia flow rate calculated and the actual flow feedback signal from the local panel.

Manual Mode: The operator manually adjusts the ammonia flow rate output signal.

4.6 Reagent Feed

The reagent feed for sulfur removal is provided by a complete, packaged pneumatic conveying system. The system accepts a 4-20 mA Network 90 output signal to control reagent flow rate. The flow demand signal generated within the Net-90 utilizes a function generator with the inlet flue gas flow (FT-100), inlet SO_2 concentration (AI-100A) desired stoichiometric ratio (moles reagent per mole of SO_2 entering), and percent available alkali in the reagent as inputs.

The local panel provides the measured reagent flow rate signal to the Net-90 for control feedback, indication and data acquisition.

Automatic Mode: The Network 90 automatically adjusts the reagent mass flow rate output signal based on the error between the calculated value and the flow feedback signal from the local panel.

Manual Mode: The operator manually adjusts the Net-90 output signal from 0 to 100% of scale.

5.0 Equipment Control

The following is a listing of object level control requirements for the individual equipment that interfaces with the control system. Where packaged systems are provided, the local control panel is considered the object level interface point for the control system.

5.1 Baghouse (BH-800)

The baghouse operation, cleaning and protection is totally provided by the vendor supplied controls and control panel.

Automatic Control:	None through the Net-90, all local control.
Manual Control:	Local Panel Only.
Indication:	Vendor Local Baghouse On-Line Baghouse in By-pass Mode Baghouse Diff. Pressure (recorder) Baghouse Compart. Temperature (6) Baghouse Inlet & Outlet Temperature
Alarms:	Vendor Local Local Panel Common Trouble Baghouse Trip High Compartment Temperature
Permissives:	Vendor Local
Interlocks:	Vendor Local A Net-90 System Trip or an operator initiated baghouse trip will trip the baghouse to the Bypass Mode
Net-90 Inputs:	
Digital:	Baghouse On-Line Baghouse in Bypass Mode Local Panel Common Trouble
Analog:	Baghouse Differential Pressure
Thermocouple:	Baghouse Inlet Temperature Baghouse Outlet Temperature Compartment Temperatures (6)

Net-90 Outputs:

Digital: High Compartment Temperature
Trip Baghouse to Bypass

Analog: None

5.2 System Gas Flow Control Damper (D-103)

Automatic Control: Reference Section 4.1

Manual Control: Reference Section 4.1

Local Control: Manual Override

Indication: Damper Closed Position
Inlet Flue Gas Flow (recorder)
System Inlet Temperature
System Inlet Pressure

Alarms: High Inlet Flue Gas Flow
Low Inlet Flue Gas Flow
Low Inlet Flue Gas Temperature

Permissives to Open: Booster Fan Running/Timer Timed-Out

Interlocks: A System Trip closes the Control Damper.

Fan Stopped - Closes Damper

Net-90 Inputs:

Digital: Closed Limit Switch

Analog: Venturi Differential Pressure
System Inlet Pressure

Thermocouple: System Inlet Temperature

Net-90 Outputs:

Digital: None

Analog: Damper Position Control

5.3 Flue Gas Heater (HX-500)

The flue gas heater operation, protection and safety functions are provided by the vendor supplied local panel.

Automatic Control:	Reference Section 4.2
Manual Control:	Reference Section 4.2
Indication:	Vendor Local Outlet Flue Gas Temp (recorder) Heater in Service
Alarms:	Vendor Local Local Panel Common Trouble Heater Trip A significant deviation from the measured outlet flue gas temperature and the desired set point.
Permissives to Start:	Vendor Local Inlet Flue Gas Flow Above Minimum
Interlocks:	Vendor Local A system trip initiates a duct burner shutdown. Flue Gas Flow < Minimum Trips the Flue Gas Heater
Net-90 Inputs:	
Digital:	Heater In-Service Heater Local Panel Trouble Heater Local Panel Trip
Analog:	None
Thermocouple:	Heater Outlet Flue Gas Temperature (four thermocouple grid to generate average for indication)
Net-90 Outputs:	
Digital:	System Permissives Satisfied
Analog:	Control Output Signal

5.4 Inlet Flue Gas Cooler Cooling Air Fan, (FN-101)

Automatic Control:	None
Manual Control:	Local
Local Control:	Start/Stop
Indication:	Cooling Air Fan Running
Alarms:	Cooling Air Fan Tripped
Permissives to Start:	Fan Inlet Vanes (D-101) Closed
Interlocks:	None
Net-90 Inputs:	
Digital:	Fan Running Fan Tripped
Analog:	None
Net-90 Outputs:	
Digital:	Fan Start Permissives Satisfied
Analog:	None

5.5 Inlet Gas Cooler Cooling Air Fan Inlet Vanes (D-101)

Automatic Control:	Reference Section 4.3
Manual Control:	Reference Section 4.3
Local Control:	Manual Override
Indication:	Closed Position Cooler Outlet Gas Temperature Cooler Block Temperatures (2)
Alarms:	Low Outlet Gas Temperature High Outlet Gas Temperature A significant deviation from the measured outlet flue gas temperature and the desired set point.
Permissives to Open:	Fan Running & Timer Timed-Out

Interlocks:	A cooling air fan trip or shutdown closes the cooling air fan inlet vanes.
Net-90 Inputs:	
Digital:	Inlet Vanes Closed Position
Analog:	None
Thermocouple:	Block Temperatures (2) Cooler Outlet Gas Temperature (four thermocouple grid to generate average for indication)
Net-90 Outputs:	
Digital:	None
Analog:	Inlet Vanes Position Control Signal

5.6 Outlet Flue Gas Cooler Cooling Air Fan, (FN-102)

Automatic Control:	None
Manual Control:	Local
Local Control:	Start/Stop
Indication:	Cooling Air Fan Running
Alarms:	Cooling Air Fan Tripped
Permissives to Start:	Inlet Vanes (D-102) Closed
Interlocks:	None
Net-90 Inputs:	
Digital:	Fan Running Fan Tripped
Analog:	None
Net-90 Outputs:	
Digital:	Fan Start Permissives Satisfied
Analog:	None

5.7 Outlet Gas Cooler Cooling Air Fan Inlet Vanes, (D-102)

Automatic Control:	Reference 4.4
Manual Control:	Reference 4.4
Local Control:	Manual Override
Indication:	Closed Position Cooler Outlet Gas Temperature Cooler Block Temperatures (4)
Alarms:	Low Outlet Gas Temperature High Outlet Gas Temperature A significant deviation from the measured outlet flue gas temperature and the set point.
Permissives to Open:	Fan Running and Timer Timed-Out
Interlocks:	A cooling air fan trip or shutdown closes the cooling air fan inlet vanes.
Net-90 Inputs:	
Digital:	Inlet Vanes Closed
Analog:	None
Thermocouple:	Block Temperatures (4) Cooler Outlet Gas Temperature (four thermocouple grid to generate average for indication)
Net-90 Outputs:	
Digital:	None
Analog:	Inlet Vanes Position Control Signal

5.8 Outlet Gas Cooler Cooling Air Recirc. Damper, (D-105)

Automatic Control:	Reference 4.4
Manual Control:	Reference 4.4
Local Control:	Manual Override

Indication:	Closed Position Inlet Cooling Air Temperature
Alarms:	Low Cooling Air Inlet Temperature
	A significant deviation of the measured cooling air inlet temperature from the set point.
Permissives to Open:	Cooling Air Fan Running
Interlocks:	A cooling air fan trip or shutdown closes the cooling air recirculation damper.
Net-90 Inputs:	
Digital:	Recirculation Damper Closed
Analog:	None
Thermocouple:	Cooling Air Inlet Temperature
Net-90 Outputs:	
Digital:	None
Analog:	Recirculation Damper Control Signal

5.9 Ammonia Injection System

The ammonia injection system operation and control is provided through the vendor local panel. The local panel accepts an ammonia flow demand signal and the system provides ammonia at the proper flow and dilution to the injection header system.

Automatic Control:	Reference 4.5
Manual Control:	Reference 4.5
Local Control:	Start/Stop
Indication:	Vendor Local Dilution Air Flow Ammonia Flow (recorder) System On-line

Alarms:	Vendor Local Local Panel Common Trouble A significant deviation from the measured ammonia flow and the set point.
Permissives to Start:	Vendor Local Gas temperature above minimum Baghouse not in Bypass Mode
Interlocks:	Vendor Local A system trip or a baghouse trip to bypass causes an ammonia system shutdown.
Net-90 Inputs:	
Digital:	Local Panel Common Trouble Ammonia System Running
Analog:	Ammonia Flow Feedback Signal Dilution Air Flow
Net-90 Outputs:	
Digital:	Trip Ammonia System
Analog:	Ammonia Flow Control Signal

5.10 Reagent Feed System

The reagent feed system operation and control interface is provided through the vendor local panel. The local panel accepts independent fresh reagent and recycle reagent flow demand signals and the system provides the desired flow to the injection point in the flue. The local panel output terminal provides independent mass flow feedback signals for the measured reagent flow.

Automatic Control:	Reference 4.6 and 4.7
Manual Control:	Reference 4.6 and 4.7
Local Control:	Start/Stop
Indication:	Vendor Local Reagent Feed System On-line Reagent Flow Rate (recorder)

Alarms:	Vendor Local Reagent Feed System Trip Local Panel Common Trouble A significant deviation from the measured reagent flow and the set point.
Permissives to Start:	Vendor Local Baghouse On-line
Interlocks:	Vendor Local A system trip initiates a reagent feed system shutdown sequence.
Net-90 Inputs:	
Digital:	Local Panel Common Trouble Reagent Feed System Running Reagent Feed System Tripped
Analog:	Reagent Mass Flow Feedback
Net-90 Outputs:	
Digital:	Trip Reagent Feed System
Analog:	Reagent Flow Control Signal

5.11 Ash Removal System

The ash removal system operation and control is provided entirely through the vendor local panel.

Automatic Control:	Local Only
Manual Control:	Local Only
Local Control:	Start/Stop
Indication:	Vendor Local Ash Removal System Running
Alarms:	Vendor Local Ash Removal System Common Trouble
Permissives to Start:	Vendor Local

Interlocks:	Vendor Local
Net-90 Inputs:	
Digital:	Ash Removal System Running Local Panel Common Trouble
Analog:	None
Net-90 Outputs:	
Digital:	None
Analog:	None

5.12 Booster Fan (FN-100)

Automatic Control:	None
Manual Control:	Local
Local Control:	Start/Stop
Indication:	Fan Running
Alarms:	Low Flue Gas Flow 30 seconds after Flow Control Damper leaves the closed position. Booster Fan Tripped
Permissives to Start:	Baghouse In Bypass Mode System Flow Control Damper Closed
Interlocks:	Outlet Flue Gas Cooler Temperature (trip if greater than 600 F). Low-low gas flow 30 seconds after the flow control damper leaves the closed position trips the fan off.
Net-90 Inputs:	
Digital:	Fan Running Booster Fan Start/Stop Switch Position
Analog:	None

Net-90 Outputs:

Digital: Trip Fan

Analog: None

5.13 Compressed Air System

Automatic Control: Local Only

Manual Control: Local Only

Local Control: Start/Stop

Indication: System Running

Alarms: Vendor Local
Low Baghouse Cleaning Air Pressure
Low Receiver Tank Pressure
Compressor Trip

Permissives
to Start: None

Interlocks: None

Net-90 Inputs:

Digital: System Running
Receiver Tank Pressure Switch
Compressor Tripped

Analog: Baghouse Cleaning Air Pressure

Net-90 Outputs:

Digital: None

Analog: None

6.0 System Trips

The following is a description of the various trip sequences for the system and individual equipment.

Note: All system or equipment trips are alarmed.

6.1 System Trip

A system trip will simultaneously perform the following:

- Trip off the flue gas heater
- Trip off the ammonia injection system
- Trip off the reagent feed system
- Trip off the booster fan
- Close the gas flow control damper
- Trip baghouse to bypass mode

The system trip is initiated on any one of the following conditions:

- Operator command
- Booster fan trip

6.2 Flue Gas Heater Trip

A burner trip is alarmed only. The operator takes any desired actions through the Net-90 control panel.

A burner trip is initiated by any of the following:

- Local panel interlocks
- System trip
- Gas flow below minimum

6.3 Ammonia System Trip

An ammonia system trip is alarmed only. The operator takes any desired action through the Net-90 control panel.

An ammonia system trip is initiated by any of the following:

- Local panel interlocks
- System trip
- Baghouse inlet temperature low
- Baghouse trip to bypass

6.4 Reagent Feed System Trip

A reagent feed system trip is alarmed only. The operator takes any desired actions through the Net-90 control panel.

A reagent feed system trip is initiated by any of the following:

- Local panel interlocks
- Baghouse trip to bypass
- System trip

6.5 Ash Removal System Trip

An ash removal system trip is alarmed only. The operator takes any desired action through the Net-90 control panel.

An ash removal system trip is initiated by the following:

- Local panel interlock

6.6 Baghouse Trip

A baghouse trip will trip the reagent feed system and the ammonia feed system. A baghouse trip puts the baghouse in the bypass mode.

A baghouse trip is initiated by any of the following:

- Local panel interlock
- System trip
- Operator command

6.7 Booster Fan Trip

A booster fan trip will perform the following:

- Generate a system trip
- Close the flue gas flow control damper

A booster fan trip is initiated by any of the following:

- High-high outlet flue gas cooler outlet gas temperature (600 F)
- Low-low gas flow 30 seconds after the flow control damper leaves the closed position
- System trip

6.8 Inlet Cooler Cooling Air Fan Trip

A cooling air fan trip will perform the following:

- Close the associated fan inlet vanes
- Sound an alarm

6.9 Outlet Cooler Cooling Air Fan Trip

A cooling air fan trip will perform the following:

- Close the associated fan inlet vanes
- Close the cooling air recirculation duct damper
- Sound an alarm

6.10 Compressor Trip

A compressed air system trip is alarmed only.

7.0 Instrumentation

The following is a listing of the instrumentation (with function, applicable ranges and set points) used for system control. Vendor supplied instrumentation for local system control are not included in this list.

AU-100 SO_2-NO_x-O_2 Inlet Flue Gas Analyzer

a. Indication

SO_2 range: 0 - 4000 ppm
NO_x range: 0 - 1000 ppm
O_2 range: 0 - 21 %

b. SO_x measurement provides input to the reagent flow rate analog control loop.

c. Data acquisition of inlet SO_2, NO_x, O_2 concentrations.

PT-100 Inlet Flue Gas Pressure Transmitter

a. Indication Range: -25 to +15 " H_2O

b. Used for pressure compensation of the inlet flue gas flow instrument, FE-100.

c. Data acquisition of inlet gas pressure.

TE-100 Inlet Flue Gas Thermocouple:

a. Indication Range: 400 to 1000 F

b. Used for temperature compensation of the inlet flue gas flow measurement, FT-100.

c. Data acquisition of inlet gas temperature.

d. Low alarm at 550 F

FT-100 Inlet Flue Gas Flow Transmitter:

a. Indication Range: 0 to 20 in WG

b. Used as control feedback to the flue gas flow control loop for control of the flue gas flow control damper, D-103.

c. Used with inlet SO_2 concentration provided from AU-100 for reagent flow control loop.

d. Data acquisition of system inlet flue gas flow rate.

e. High alarm at 27000 ACFM.

f. Low alarm (30 seconds after damper D-103 opens) at 10000 ACFM.

g. Low flow, less than 8000 ACFM, trips flue gas heater.

h. Low-low gas flow (30 seconds after damper D-103 opens) trips the booster fan at 6000 ACFM.

TE-101 Flue Gas Heater Outlet Thermocouples (4)

a. Indication Range: 400 to 1400 F

b. Average used for control feedback to the burner outlet flue gas temperature control loop.

c. Data acquisition of sulfur sorbent injection point flue gas temperature.

TE-102 Inlet Flue Gas Cooler Outlet Thermocouples (4)

a. Indication Range: 400 to 1200 F

b. Average used for control feedback to outlet gas temperature control loop fan inlet vane (D-101) positioner.

c. Data acquisition of ammonia injection point temperature.

d. High alarm at 1000 F. Low alarm at 500 F.

e. Temperature permissive for ammonia injection. Must be above 500 F.

f. Used for temperature correction of baghouse inlet gas flow measurement, FT-101.

PT-101 Inlet Cooler Outlet Gas Pressure Transmitter

a. Indication Range: -25 to +5 " H_2O

b. Used for pressure correction of baghouse inlet gas flow measurement, FT-101.

AU-101 SO_2-NO_x-O_2 Baghouse Inlet Flue Gas Analyzer

a. Indication

SO_2 range: 0 - 4000 ppm
NO_x range: 0 - 1000 ppm
O_2 range: 0 - 21 %

b. Provides input for the ammonia flow rate analog control loop.

c. Data acquisition of baghouse inlet SO_2, NO_x, O_2 concentrations.

FT-101 Baghouse Inlet Flue Gas Flow Transmitter

a. Indication range: 0 to 20 in WG

b. Flow value is used with baghouse inlet NO_x concentration provided by AU-101 for ammonia flow rate analog control loop.

c. Flow value is used with NO_x concentration from analyzer AU-101 for ammonia flow control loop.

d. Data acquisition of baghouse inlet gas flow rate

AU-102 SO_2-NO_x-O_2 Baghouse Outlet Flue Gas Analyzer

a. Indication

SO_2 range: 0 - 2000 ppm
NO_x range: 0 - 500 ppm
O_2 range: 0 - 21 %

b. Used with baghouse outlet volumetric gas flow and outlet temperature and pressure for baghouse SO_2 and NO_x removal efficiency calculations.

c. Data acquisition of baghouse outlet SO_2, NO_x, O_2 concentrations

OU-800 Baghouse Outlet Opacity Analyzer

a. Indication range: 0 to 10 %

b. High alarm at 5%

c. Data acquisition of system outlet opacity

TE-105 Outlet Flue Gas Cooler Outlet Thermocouples (4)

a. Indication range: 100 to 700 F

b. Average used for control feedback to outlet gas temperature control loop fan inlet vane (D-102) positioner.

c. Low alarm at 150 F ; High alarm at 400 F

d. Data acquisition of cooler flue gas outlet temperature (booster fan inlet temperature)

TE-108 Outlet Gas Cooler Cooling Air Inlet Thermocouple

a. Indication range: -20 to 150 F

b. Used for control feedback to inlet cooling air temperature control loop damper (D-105) positioner.

c. Low alarm at 95 F

PT-903 Baghouse Cleaning Air Pressure

a. Indication range: later

b. Low alarm at later.

PS-901 Receiver Tank Pressure Switch

a. Low alarm at later.

8.0 Data Acquisition

This section summarizes the inputs to the Net-90 system that shall be indicated and transferred to the data acquisition system.

1. System inlet SO_2 concentration, (AI-100A)
2. System inlet NO_x concentration, (AI-100C)
3. System inlet O_2 concentration, (AI-100B)
4. System inlet flue gas pressure, (PI-100)
5. System inlet flue gas temperature, (TI-100)
6. System inlet flue gas flow rate, (FR-100)
7. Flue gas heater outlet gas temperature, (TR-101, the average of measurements from TE-101 A,B,C,D)
8. Sorbent injection point temperature, (TI-115, 116, 117)
9. Inlet cooler block temperatures, (TI-113 and TI-114)
10. Baghouse inlet pressure, (PI-101)
11. Inlet flue gas cooler outlet) flue gas temperature, (TI-102, the average of measurements from TE-102 A,B,C,D)
12. Flue SO_2 concentration, (AI-103A)
13. Flue O_2 concentration, (AI-103B)
14. Baghouse inlet SO_2 concentration, (AI-101A)
15. Baghouse inlet NO_x concentration, (AI-101C)
16. Baghouse inlet O_2 concentration, (AI-101B)
17. Baghouse inlet flue gas flow rate, (FI-101)
18. Baghouse differential pressure, (PDR-006)
19. Baghouse inlet flue gas temperature, (TR-007)
20. Baghouse outlet ammonia analyzer, (AI-104)
21. Baghouse compartment outlet opacity, (AI-80x, x=1-6)
22. Baghouse compartment temperature, (TI-x06, x=1-6)

23. Baghouse outlet flue gas temperature, (TI-later)

24. Baghouse outlet SO_2 concentration, (AI-102A)

25. Baghouse outlet NO_x concentration, (AI-102C)

26. Baghouse outlet O_2 concentration, (AI-102B)

27. Baghouse outlet opacity, (AI-800)

28. Outlet flue gas cooler outlet gas temperature, (TI-105, the average of measurements from TE-105 A,B,C,D)

29. Outlet flue gas cooler block temperatures, (TI-109, 110,111,112)

30. Outlet flue gas cooler cooling air inlet temperature, (TI-108)

31. Baghouse cleaning air pressure, (PI-903)

32. Ammonia flow rate from ammonia injection system local panel, (FR-400)

33. Dilution air flow rate from ammonia injection system local panel, (later)

34. Reagent flow rate from reagent feed system local panel, (FR-200)

TAB 3

PROCESS FLOW SCHEMATICS/MASS AND ENERGY BALANCES

DRAWING NUMBER	TITLE
421660E-1	Mass and Energy Balance - 100% Design Flow
421661E-1	Mass and Energy Balance - 50% Design Flow

TAB 4

SITE PLAN AND GENERAL ARRANGEMENT DRAWINGS

DRAWING NUMBER	TITLE
12515J-0	General Arrangement SNRB Plot Plan
12584J-1	SNRB Equipment Area Plan View, Section B-B
12585J-1	SNRB Equipment Side View
12587J-1	SNRB Silo Area Plan View
12588J-1	SNRB Silo Area Elevation View
12589J-1	SNRB Equipment Area Plan View, Section A-A

TAB 5

PROCESS AND INSTRUMENT DIAGRAMS

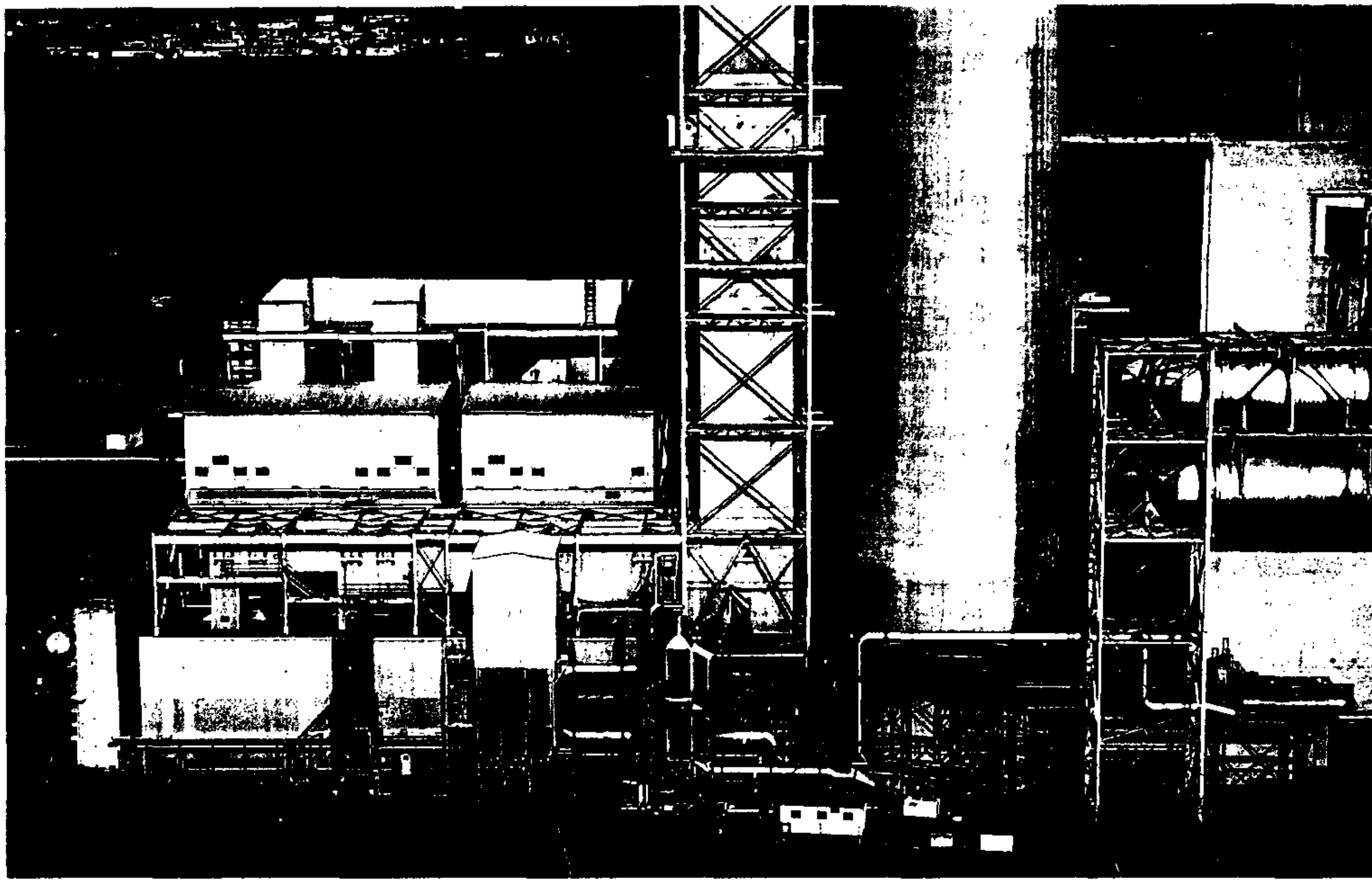
DRAWING NUMBER	TITLE
416975E-1	Schematic Process & Instrument Diagram
416976E-2	Schematic Process & Instrument Diagram
416992E-2	P&ID Compressed Air System
416993E-2	P&ID Service & Instrument Air
416994E-2	P&ID Service & Potable Water

P&IDs for the following systems are considered proprietary and are not included in this public design report:

- Baghouse and Baghouse Controls
- Propane Facility
- Ammonia Storage and Air System
- Reagent Feed System
- Ash Conveying System

a McDermott company

SNRB Clean-Coal Technology Demonstration



The SO_x-NO_x-Rox-Box (SNRB) process, developed by the Babcock & Wilcox Company, is an advanced system for controlling air pollution. The unique process combines the removal of sulfur oxides (SO_x), nitrogen oxides (NO_x), and particulates (Rox) emitted from fossil-fired boilers using alkaline sorbent and ammonia injection ahead of a high-temperature baghouse.

The 5-MWe SNRB demonstration facility is located at Ohio Edison's R.E. Burger power plant near Shadyside, Ohio (right). Along with B&W, the U.S. Department of Energy, the Ohio Coal Development Office, the Electric Power Research Institute, and Ohio Edison are primary sponsors of this clean-coal project.

Operation of the Burger pilot plant has demonstrated greater than 70% removal of SO_2, 90% reduction in NO_x emissions, and particulate emissions lower than 0.03 pound per million Btu.

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